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Overview of Uses of Palms with an Emphasis on Old World and Australasian Medicinal Uses

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Overview of Uses of Palms with an Emphasis on Old World and Australasian Medicinal Uses

by

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Dedication

This report is dedicated to Dr. Beryl B. Simpson. Her scholarship, support, and strong work ethic have aided and inspired me immensely during my time in this program.

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Overview of Uses of Palms with an Emphasis on Old World and Australasian Medicinal Uses

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This report details the significance of the palm tree family or Palmae in the lives of humans. In chapter one, I summarize major palm uses around the world. As sources of products important to the world economic market, palms are ranked as one of the top three plant families. If additional products from national and local level markets are also considered, palms could possibly be the most important plant family to humans. A tremendous number of species are utilized across the world, mainly in subtropical and tropical areas, as vital sources for food, fiber, fuel, and medicine.

The unique morphological and anatomical characteristics of palms are responsible for their great utility. These attributes are discussed in conjunction with the many uses they provide. A few species have been important in the lives of humans from some of the first civilizations; many of these species are still as

important. Such a long history of interaction has also led to palms being interwoven into the religious and mythical frameworks of various societies and tribes. In chapter two, I detail the occurrence of medicinal uses for Old World and Australasian palms. Palms as novel sources of medicinal compounds have been underappreciated. A few papers in the last few decades have found a substantial number of medically relevant uses of Neotropical palms. As a parallel, this report presents medically relevant uses discovered in the last few decades for Old World and Australasian palms. Similar to Neotropical palms, the remainder of the world's palms could possibly be important sources of medicines for more frequent traditional use and as possible sources for drugs created for application in conventional medical settings. An increasing awareness of palms as important sources of medicines could have implications for their conservation.

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Chapter I

An Overview of the Economic Botany and Ethnobotany of Palms

Plants provide resources humans need for survival. Three diverse and widely distributed plant families, the Poaceae, Fabaceae, and Palmae, are the source of the worlds most important and abundant plant products (Johnson, 1996). The first two supply nutritious beans and grains that feed most of humanity. For its sheer versatility of uses, the Palmae or palm tree family is the most important family in the lives of forest peoples throughout the tropics (Campos and Ehringhaus, 2003).

The Palmae consists of around 280 genera and 2800 species (Govaerts and Dransfield, 2005). They are mainly restricted to tropical and subtropical regions; a few outlier species grow in Mediterranean, temperate, and semi-arid habitats. The greatest palm species diversity is in the Asian and Neotropics, but they are poorly represented in mainland Africa. Notable smaller scale regions of high species richness are New Caledonia, Madagascar, and Borneo (Dransfield et al., 2008). Palms grow abundantly in a diverse range of tropical and subtropical habitats; wet lowland rainforests, within mangrove swamps, beside rivers, in savannahs, and throughout high mountainous regions. Non-human mammals rely on palms in some of these habitats for survival, thus indigenous peoples use palm populations as important hunting grounds (Zona and Henderson, 1989). Humans use almost every morphological and anatomical feature palms exhibit; the number of products derived from them is legion.

Palms have one of the richest fossil records of any plant group, in the form of leaves, stems, and pollen. Using this fossil record, researchers have suggested that the family arose in the mid-Cretaceous and divided into all major subfamilies by the early tertiary (Dransfield et al., 2008). With such a long exposure to changing environments worldwide, palms have evolved exceptionally rich anatomical and morphological diversity. The evolutionary significance of most morphological and anatomical features in the Palmae is not known. Regardless, these evolutionary novelties are the underlying reason palms have yielded such a plethora of useful products for humankind.

Palms are the most morphologically diverse of any monocot family and possibly of any plant family (Dransfield et al., 2008). They range in height from a few inches to a lofty 200 feet in the genus *Ceroxylon*, which inhabits high elevation forests of the Andes (Henderson et al., 1995). Palm leaves are constructed into two main forms: pinnate and palmate. Pinnate leaves are divided into two halves by a central midrib. On either side of the midrib the leaf can be undivided or segmented into numerous narrow and linear leaflets. In African species of the genus *Raphia*, pinnate leafs of over 75 ft long with hundreds of leaflets have been observed (Dransfield et al., 2008). Palmate leaves have a reduced or entirely absent midrib. Connected directly to the reduced midrib or the petiole, the leaf can divide into numerous leaflets or remain undivided. In the genus *Borassus*, segmented palmate leaves can reach 25 feet in diameter (Tomlinson, 2006). Palm leaves are generally larger than those of other monocots. Both palm and monocot leaves have a similar anatomical makeup and extremely fibrous and linear, waterproof leaves or leaflets. Due to their fibrous nature and waterproof abilities, these leaves can withstand hurricane force winds and the destructive power of insects and fungi (Jones, 1995). Most palm inflorescences are immense, which can make collecting them for scientific purposes burdensome and labor-intensive (Dransfield and Beentje, 1995). The Talipot Palm (*Corypha umbraculifera*) has the largest inflorescence in the plant kingdom, reaching up to eight meters on some individuals (Hammer, 1984). By contrast, palm flowers are small and inconspicuous and often creamy-white in color. These flowers are predominately pollinated by beetles, bees, and secondarily by wind (Anderson and Overal, 1988). Beetles are, by far, the most abundant and widespread group of pollinators (Dransfield et al., 2008). Once fertilized, the resulting fruits and seeds exhibit an array of sizes, shapes, and colors. In fact, the largest seed in the plant kingdom comes from a palm; the bi-lobed, buoyant seed of Coco de Mer (*Lodoicea maldivica)*, a monotypic genus from the Seychelles, can weigh up to 4 lbs and reach 1.5 feet wide (Dransfield et al., 2008).

Currently, the products of four palms play a dominant role in world economic markets: (1) the African oil palm, (*Elaeis guineensis*), for example, yields almost 21 million tons of fruit annually to supply the increasing worldwide demand for vegetable oils (Koh and Wilcove, 2007). Large, centralized processing facilities with modern fractionation technology are needed in order to press and fractionate high quality mesocarp oil properly to manufacture cosmetics, margarines, biofuels, and lubricants. Lower quality oil is also pressed from the endosperm to be used for soap production and in food production (Hodge, 1975). These same industrial procedures are needed to extract oil from the endosperm of (2) the Coconut (*Cocos nucifera*), which makes up 20% of all the vegetable oil on the world market and represents billions of dollars in production revenue (Jones, 1995; UNFAO, 2007). Over a thousand other uses are known for coconut trees worldwide; however, these uses are mostly manufactured or produced on a local level (Jones, 1995). People throughout Southeast Asia and Africa harvest wild populations of (3) rattan. Rattan comes from the subfamily Calamoideae; defined by the key characteristic of red-orange, scale-like fruits. Over 25 rattan species in Africa and 550 species in Asia are harvested for their pliable stems (Dransfield, 1981). Stems of a few species are the longest in the plant world, some reaching up to 600 feet (Tomlinson, 2006). These stems wind along the forest floor for long distances until their modified thorn-like leaves grapple onto tall, vertical trees, moving up towards the sunlight. People pull rattan from their attachments on other trees to a forest clearing, where the first few cellular layers of the stem are stripped off. These strips do not go to waste; they are used for weaving. The remaining stem sections are soaked in insecticides, some species are bleached with sodium hydroxide, and they are then sent to distribution centers for weighing, inspection, and transport to China (Peters et al., 2007). In China, pliable rattan is used commercially for furniture construction, yielding 6.5

billion dollars in annual revenue (ITTO, 1997). Rattan is also used for bridges, ropes, bows and arrows, leaf thatch, fishing lines, leaves for ceremonial buckets, and to extract drinking water from the pith of the stem (Dransfield, 1974). Despite being shipped worldwide and netting billions of dollars in revenue, the fruits of (4) the date palm (*Phoenix dactylifera*) only need a limited amount of industrial processing (FAOUN, 2007). One of only a few palms capable of surviving in the extreme, dry heat of desert regions, date palms have been cultivated for millennia for their sugar rich, nutritious fruits. Once harvested, the fruits are taken to a processing facility where they are dried and packaged for regional distribution or worldwide export (Jones, 1995).

Most products extracted from other palms around the world are only important on a national, regional, or local level. As such, many of the harvested palm parts only require cottage-level or small-scale industrial processing. The peoples of indigenous communities have also retained many palm uses. It is these people who have the most intimate and direct relationship with palms and who have the most experience in understanding how to extract the natural products of their environment in a sustainable manner (Johnson, 1996). Not surprising then, even though some overexploitation of palms occurs in local villages, the most prevalent and destructive overexploitation of wild palm populations comes from small and large scale commercial harvesting for national and world markets (Jones, 1995).

The dependency of people on palms is remarkable. Only fragmentary evidence yields clues to the possible origin of this relationship. In the Middle East and Asia, palms were idealized on ancient writings and on the temple reliefs of great civilizations (Padmakumar and Sreekumar, 2003; Dransfield, 1976a; McDonald, 2002). Depictions of palms have also been found on wooden vases from the Incan empire (Vargas, 1981). No doubt, though, human association with palms began much earlier. This long relationship has allowed traditional peoples, due to their adept biological observations and experimentation, to harvest from the anatomical and morphological diversity of palms and create an amazing number of life sustaining products. Throughout history, explorers, rural immigrants, and researchers from industrial nations have slowly gained a limited understanding from indigenous people of various palm products.

The palm stem is unique. As it develops and grows, it lays down vascular bundles in an organized, yet dispersed manner throughout the stem. Between these conductive regions are cells specialized to store water and starch. On the peripheral part of the stem, totipotent parenchyma cells differentiate into a thick section of elastically strong fiber cells. Humans have taken advantage of these unique anatomical qualities for food, shelter, and weapons.

Many species of palms store useful starch known as sago in the stems storage cells; many tropical peoples in Asia and the South Pacific extract this sago. By far, the most widely utilized palm for this purpose is the Sago Palm (*Metroxylon sagu*), which thrives in moist, even highly saline, soil conditions and is harvested by traditional peoples in Southeast Asia, Melanesia, and a few islands in Polynesia (McClatchey, 1992). This palm species is monocarpic; thus, the tree is felled before most of the stems sago is hydrolyzed and transported to the emerging terminal inflorescence that signals the death of the tree. *Metroxylon sagu* generally only lives for 11-12 years (McClatchey et al., 2006). The section of the stem containing starch storage cells is cut away from the surrounding fiber cell masses. This tissue is then grated into water, mixed thoroughly, and passed through a palm fiber sieve. As the mixture passes through the tight netting of palm fibers, the starch is filtered from the water. Starch granules precipitate together; then too wide to pass through the filter, they accumulate within the sieve. The accumulated starch is eventually transferred from the sieve to be sun or kiln dried for production of “wet” sago (Singhal et al., 2008). One *M. sagu* stem can yield up to 400 pounds of sago (Shipman, 1967). This traditional method of sago extraction has been almost entirely disappeared in certain areas of Southeast Asia.

With a possible looming world food crisis and evidence that large influxes of anthropogenic-mediated carbon emissions are causing global warming, many world nations are scanning the globe for previously untapped plant resources. *Metroxylon sagu* has come to the attention of the industrialized world as an important resource for mass starch extraction, biofuel production, and as a carbon sink for carbon sequestration. Modern industrial processing of sago from this palm is already commonplace and yields a starch product known as “dry” sago; this sago is considered to be of a higher quality than “wet” sago (Singhal et al, 2008). In this method, stems are cut, floated down river to processing centers, and specialized saws extract the conjunctive tissue. This tissue is immediately transferred to water-filled, mechanized filtering devices that are able to purify the starch from the water with better success than the traditional method. The rural communities and traditional peoples living in the sago producing regions of Southeast Asia have almost entirely abandoned traditional extraction methods in favor of the preferred "dry" sago (Stanton, 1993).

The dense and thick sections of fiber cells laid down on the periphery of the palm stem give it immense strength. In myriad tropical villages, the supporting posts, structural timbers, and floorboards of shelters are derived entirely from palm stems of many species. Many shelters have multiple stories; ladders are fashioned from palm stems by carving notches up their length (Jones, 1995).

For numerous tribal groups, palm stems have supplied instruments for hunting and war such as: clubs, spears, blowpipes, daggers, arrows, bows and spines for darts (Hodge, 1957; Jones, 1995; Johnson, 1996).

The stem of most palms has only one growing or apical meristem region. If this region is destroyed, the stem cannot continue to grow. Multiple stems may have evolved to combat this problem. In a few palms, meristems exist at the base of the stem. From there, many stems can emerge and develop into a cluster. Even rarer are palms that exhibit below and aboveground dichotomous branching (Dransfield et al., 2008). For additional protection, each apical meristem is sequestered into the interior of a fibrous leaf base mass (Tomlinson, 2006). Regardless, humans have learned how to penetrate deep into this fibrous mass and extract the most tender layers to be eaten as "palm cabbage" or "palm heart." The most highly sought after palm heart has a sweet nutty flavor and is a rich source of vitamins; however, most palm hearts are bitter and some are even poisonous (Dransfield and Beentje, 1995). Unfortunately, most palms felled for apical meristem extraction are single-stemmed species. In Brazil and Paraguay, millions of individuals of the single-stemmed palm species *Euterpe edulis* are cut down from wild populations annually. This has caused low stand density and extinction in a large area of the palms' natural range. The loss of this palm has also had a profoundly negative impact on biodiversity loss of mammal and bird species in the Atlantic Rainforest of Brazil. This overexploitation is the result of large-scale industrial harvesting and small-scale cottage level harvesting by large influxes of poverty-stricken peoples (Matos and Bovi, 2002).

In Madagascar, palm heart extraction is also the result of economic and environmental instability. Increasingly, many poorer countries have been burdened with debt from trying to keep up in the modern global market. To offset these debts, wild plant products have been replaced with intensively grown agricultural products. Accordingly, some traditional peoples have lost access to wild plants due to deforestation, while others have increased their reliance on wild foods due to heightened prevalence of food scarcity. With more frequency, traditional peoples in Madagascar are harvesting wild palm populations for palm heart (Byg and Balslev, 2001b). The palm flora of Madagascar is one of the most diverse of anywhere on the planet with over 180 endemic species; most of these are already severely threatened due to deforestation; overexploitation for palm heart is now adding to this threat (Dransfield and Beentje, 1995).

Palms synthesize fiber cells with resistant and elastic strength to protect against herbivory and harsh environmental extremes. Leaf bases are especially rich in fibers; in some species they even resist saltwater degradation and exhibit antibacterial activity (Jones, 1995). Humans have taken advantage of palm leaf base fibers for a range of products. These include: cord, containers, blowdarts, medicines, tinder, thatch, and baskets. All fiber products derived from palm leaf bases are known as piassaba or piassava. The leaf base fibers of six palm species are utilized for this purpose: the Brazilian species *Leopoldinia piassaba* and *Attatlea funifera*, and three African species within the genus *Raphia* (Henderson et al., 1995; Dransfield et al., 2008). Harvesting of piassaba from *Attalea funifera*, for national and world markets, is perhaps one of the oldest economic enterprises in the New World (Voeks, 1988). Prior to synthetics, *A. funifera* piassaba was an important commodity on the world market, but now is only nationally, regionally, or locally important in Brazil. The piassaba from both *L. piassaba* and *A. funifera* are extracted from wild populations to manufacture heavy brooms, industrial brushes, as well as cords and ropes (Voeks, 1988). The petiole attaches the leaf base to the leaf. Similar to leaf bases, petioles are constructed with many layers of strong fiber cells. Accordingly, they are used for shelter wall construction and for lower quality fiber extraction (Jones, 1995). The attached leaves do not contain as many fibrous layers as petioles and piassaba, but the quality of their fiber is the best.

The most conspicuous and distinctive palm organ is the leaf itself (Dransfield et al., 2008). Each leaf type has seemingly adapted palms to a range of different environmental conditions. These different forms have all become important to humans. In fact, of any palm organ used by humans, the leaf is by far the most widely used (Jones, 1995; Johnson, 1996). In Madagascar, the top layers of *Rhaphia farinifera* leaflets are stripped and retted to produce high quality fibers called raffia used for basketry, and clothes (Dransfield and Beentje, 1995). Palms growing in desert or seasonally dry regions often excrete copious amounts of wax onto the upper or adaxial surface of their leaves to augment the water conservation qualities of cutin. Moreover, proteins within these waxes are thought to elicit chemical resistance to microorgamsims (Cruz et al, 2002). The Carnauba Wax Palm, *Copernicia prunifera*, grows in seasonally dry deciduous forests and gallery forests of Brazil and Paraguay; carnauba palm populations in these countries have been estimated at over a billion individuals. Wax obtained from the leaves can be processed into three main types of which the “yellow” type is considered the highest quality (Andrade and Salgado, 1945). The comparatively hard wax is collected from both wild and cultivated populations. Carnauba wax has been used for the production of paints, enamels, chalk, wallpaper, candles, lipsticks, shoe and car polish, floor wax and for insulating electrical machinery (Jones, 1995; Beckett, 1943). In many instances, carnauba wax has been replaced by synthetics, but it is irreplaceable for some uses. Carnauba was the only wax suitable for sealing cracks in Michelangelo's Pieta, as it more appropriately matched the texture, color and temperature qualities needed (Moore, 1973).

Palm leaf waxes act in association with their many fibers to prohibit herbivores from causing damage and pathogens from gaining access into the leaf. These attributes did not go unnoticed by indigenous peoples for whom palm leaves were a natural choice for roofing material in traditional societies. While leaves are still the primary means of roofing in many tropical indigenous communities (Dransfield et al., 2008), in many areas they have been replaced by cement walls and tin roofs as housing construction materials. Balick (1988) reports that the Guajajara tribe, of the Amazonian basin, constructs traditional palm shelters next to modern ones to be used during the hottest weather periods. Palm shelters are more effective in maintaining coolness, dryness, and air movement.

Inflorescences emerge either from among leaves, reduced leaves (bracts), or from below the palm crown. In monocarpic palms, all inflorescences emerge at the distal portion of a stem from among reduced leaves or bracts. Both other types of emerging inflorescences will occur periodically after reproductive maturity. For sugar and alcohol production people regularly tap the metabolic resources that are transferred through inflorescences during flowering. Many palms have been recorded for this purpose, but the sugary sap extracted from species in three Asian genera dominates world palm sugar production. The appropriately named Sugar Palm (*Arenga pinnata*), Toddy Palm (*Caryota urens*), and the widely used Palmyra Palm (*Borassus* spp.) are all extensively tapped for sugar production. An incision is made at the distal end of the inflorescence and a bucket, fashioned from palm leaflets, is attached to collect the exuding sap. The collected sap is especially rich in sugar but in *Arenga pinnata*, the sap has been shown to contain a large amount of proteins (Plotkin and Balick, 1984). Interestingly, Miller (1964) suggests that *Arenga pinn*ata was possibly the first palm to be used for economic purposes in the Old World; its sugar was used as a trade item. In India, the Palmyra palm provides sugar or jaggery for consumption or trade. In dense wild stands or planted rows of *Borrasus flabillifer* one man can extract two liters from 30 trees a day for 30 days, resulting in considerable yields (Dransfield, 1976b). As sap runs out of the inflorescence and into the collecting buckets, endemic yeast and other alcohol-producing microorganisms on the inflorescence colonize it. Many people in Southeast Asia enjoy the palm wine or toddy produced from this natural fermentation process. Distillation of the toddy yields gin and a stronger alcoholic drink known as arrack.

In other palms, sugar solutions can be extracted by cutting leaves at the base. *Nypa fruticans* grows in dense oligarchic stands in mangrove habitats in many parts of Southeast Asia. One hectare of this palm can yield an estimated ten thousand liters of toddy, three metric tons of sugar, and four thousand liters of alcohol (Duke, 1977). Accordingly, this palm has been considered as a sustainable, commercial source of fuel alcohol (Newcombe et al, 1980). Considering that many of these sugar palms grow in habitats not hospitable to many other plants, they could be used as biofuel sources without directly interfering with food crops grown on more favorable and fertile land.

Palm fruits form on the inflorescence after pollination and fertilization. They have the potential to produce enough of a sustainable fuel resource to initiate a "Real Green Evolution" (Duke, 1977). They not only supply fuel to millions of people across the world, but also food, fiber, and medicine, although the first two are the most common. In South America, fruits from the Pejibaye or Peach Palm (*Bactris gasipaes*) have been widely harvested since pre-Colombian times as a food staple and for additional income. After boiling the fruit, the mesocarp is removed, kneaded, flattened and fried to make tortillas or added as is and cooked with eggs and chilies (Almeyda and Martin, 1980). Another South American palm fruit that is celebrated for its taste and potential health benefits is the Acai Palm (*Euterpe oleracea*). In recent years, this fruit has reached the world market and has been touted as a healthy source of antioxidants and added to smoothies, teas, or sold as a concentrate. Recent research suggests the purple pigmentation of the outer fruit layers is rich in anthocyanins and flavanoids, thus acting to mitigate health problems (Schauss et al, 2006). The fruits of the Betel Nut Palm (*Areca catechu*) are also purportedly medicinal and used for diarrhea, edema, and as an anthelmintic. Many alkaloids are present in the endosperm of this fruit; the primary active alkaloid, however, is arecoline. In high concentrations this alkaloid is thought to be carcinogenic (Saikia and Vaidehi, 1983). Many people throughout Southeast Asia use this seed as a masticory; in fact, this seed has been utilized in this manner for at least 2000 years and is the most abundant and wide-ranging masticory habit in the world (Chang and De Vol, 1973). A quartered segment of the betel nut seed is wrapped in the leaves of *Piper betel* (Piperaceae) with the addition of slaked lime flavored with spices or tobacco. Once in the mouth, the masticory recipe acts in concert to release the alkaloid, which colors the mouth reddish-orange; in many betel nut chewing areas, streets are dyed red from spit.

In the New World, *Attalea* fruit provide a full spectrum of uses to people from Mesoamerica to southern South America. Two *Attalea* species from Brazil, *A. phalerata* and *A. oleifera*, are collectively known as Babassu and are regarded as the Brazilian "Trees of life" (Anderson and Balick, 1988; Anderson and Anderson, 1985). Almost all parts of these fruits are put to use. The epicarp or outermost fruit tissue layer is used as a primary fuel source, burned for cooking and other activities. The inner, adjacent mesocarp yields a high concentration of oil that is extracted by boiling the crushed mesocarp; this oil is used for cooking and for conversion into fuel alcohol. After the oil is extracted, the remaining mesocarp fibers are used as livestock feed. The innermost strongly fibrous endocarp layer is burnt in high temperature fires for conversion into charcoal and gas (Calmon et al. 1977). Within the endocarp layer are the palm kernels or endosperm. The endocarp is difficult to crack; this is the limiting factor keeping this palm from competing on the world market with the dominant African oil palm. Once extracted from the endocarp, the kernels are pressed for flavorful cooking oil (Markley, 1963). The oils extracted from these palms have high lauric acid concentrations and are favored over coconut and African oil palm oil for soap making (Hausman, 1934). In the space present between the kernels and their endocarp cavity, are varying amounts of liquid endosperm. Chemical analysis of this liquid revealed that it is analogous to human milk, with even higher iron concentrations, a possible economic and widely available alternative to human milk for Brazilian infants (Diaz, 1976). Interestingly, the Makunas tribe of the Amazon Basin views another South American oil palm (*Oenocarpus batua*) as the incarnation of female ancestors and its fruits as breasts providing life-sustaining milk (Shultes, 1974).

Considering the importance of palm trees in providing so many of man's needs, it is not surprising palm have come to be revered, idealized, ritualized, and mystified. Palms have been significantly linked to many of the world's most widely practiced religions, but a greater abundance and diversity of palm-associated mythological and magico-religious belief systems have been held by indigenous societies (Shultes, 1974). Many inscriptions of the date palm are present on temple reliefs and ancient scrolls of Middle Eastern cultures. As such, many scholars have interpreted the date palm to be the Middle Eastern "Tree of Life." Andrew McDonald (2002) acknowledges that the date palm is ubiquitous on scrolls and engravings during this period, but argues that the date palm is only illustrated in an historical context and does not have any mythological connections. Regardless, the date palm represents important symbolic designations in Christianity, Judaism, Islam, Hinduism, Buddhism, and in ancient Greek mythology (Shultes, 1974). Palms have been repeatedly proposed as the most important group of plants for Amazonian forest peoples (Campos and Ehringhaus, 2003); not surprisingly, these peoples have many examples of palm-spirit associations. In the Colombian Vaupes, the Kubeos believe that the souls of the children of medicine men live in the large spathes of *Attalea luetzelburgii*. To avoid disturbing these souls, Kubeo hunters never enter forests where this palm species grows. Witoto hunters keep a clear distance from the chambira palm (*Astrocaryum vulgare*). They believe evil spirits shoot darts into passing humans by using the spines protruding from the stem of this palm. If someone is injured by one of these spines and incurs sickness of the spirit, the only remedy used is a beverage made from the fruits of the miriti palm (*Mauritia flexousa*)(Shultes, 1974). G. Reichal-Dolmatoff (1989) gives a detailed description of the Yurupari Complex practiced by these same tribes and many others in the Colombian Vaupes. Young boys coming into puberty are brought through the Yurupari Complex, which as defined by Reichel-Dolmatoff is "a patriarchal foundation myth containing a social code which explains and exhorts exogamy." Musical instruments for these Yurupari social events, trumpets and flutes, are fashioned from the stem of the Buhu-Nyu Palm (*Socratea exorrhiza*). The initiates blow on these instruments to remind the rest of the tribe of the once terrible tribal practice of endogamy and matriarchal rule. Once blown, these sounds send the women running to the large communal houses or malocas. Women are forbidden to catch sight of or touch the trumpets or the flutes; in many cases, women have been put to death for such an act. The entire stimulus for these rituals and beliefs are derived from observing the reproductive biology of endemic palms in the surrounding forest.

By closely observing the palm pollination process, these indigenous peoples have designated the dioecious nature of specific palms (exogamy-like behavior) as their model for male-dominant behavior. Inherent within this model are a series of associated rituals, social norms, and belief systems. In conjunction with visual perception, these people use their olfactory, auditory, and palpatory senses to evaluate the biological cues of palm inflorescences. Various palms in the region exhibit monoecy, but it is forbidden for women to acknowledge that such a botanical fact exists.

The once common ritualistic practice of writing sacred religious text on palmyra palm leaflets has almost been entirely forgotten. The Palmyra Palm (*Borassus spp.*) is revered all across Southeast Asia and grows abundantly on coastal sandy plains (Dransfield et al., 2008). An ancient Tamil poem gives over 800 traditional uses for species in this genus (Seemann, 1956). In India, Sri Lanka, and Burma, the leaves of the Palmrya Palm have long been used for writing horoscopes, Ayurvedic manuscripts, and sacred religious texts; in turn, the palm has reached a sacred status. In fact, while papyrus, vellum, or clay was primarily used for paper in other ancient civilizations, early Hindu and Buddhist peoples used *Borassus* leaves (Kinkeldey, 1941). As a sacred ritual, Hindu children still write out their first alphabet on palmrya palm leafs; the only other people still practicing this ritual are astrologers, writing out horoscopes (Padmakumar and Sreekumar, 2003). However, entire libraries of palm leaf folios still exist, housing ancient and rare collections of important Hindu and Buddhist texts (Champa, 2006). More research of ancient world cultures and traditional forest peoples may uncover many more examples of how palms have helped shape the collective mythic, ritualistic, and religious thoughts of humans.

The full spectrum of biological insight that traditional peoples use to evaluate the natural world has allowed them to develop an extensive use system for the Palmae. Essentially, traditional peoples learned to survive and adapt better in their environments by identifying important forms and functions of palms. Ironically, the underlying reason palms yield such a versatile range of products results from their own long evolutionary process of adapting to a variety of dynamic spatial and temporal environments. Many indigenous societies are adept in cultivating palms and extracting palm resources in a sustainable manner. In fact, many traditional and rural peoples around the world still practice ancient palm cultivation techniques such as cropping and intercropping (Johnson, 1985b). Rural farmers in Asia increase their income by planting bananas, yams, and citrus between Betel Nut Palms (Bhat, 1974).

In Brazil, land to be used for cattle ranching is burned to clear out all primary vegetation. The only large tree to survive this practice is the palm *Attalea phalerata*; previously felled, these palms are now kept in the fields to be used. Besides providing shade for cattle, maintaining soil moisture, and producing soil organic matter, they provide fruit for oil production that gives many millions of people in the region, especially the poverty-stricken rural and indigenous, a year-round income (Anderson and Anderson, 1985; May et al., 1985). In parts of Africa experiencing desertification, the only viable crop that can be planted is the Gingerbread Palm (*Hyphaene spp.*). Many useful products can be extracted from this palm and at the same time it partially restores soil fertility and maintains soil moisture content, enough to allow eventual intercropping of other food crops (Cook, 1946). Research focusing on these types of sustainable and restorative agricultural practices is imperative as the best modern approach to alleviating food scarcity and shortages in impoverished tropical areas of the world.

Future food and resource shortages worldwide will probably intensify the search for underutilized palms as sources of starch and biofuel for world nations determined to maintain high energy and resource inputs. As such, the integration of palms into agricultural systems, as sources of increasing world energy and resource needs, can be an integral part of sustainable, environmentally sound, and low-input farming practices. While simultaneously needing to guard their intellectual property rights from being mined for the sole purpose of economic gain by other peoples, indigenous groups hold the key to helping the rest of the world understand how to utilize palms sustainably as non-wood forest products. When indigenous peoples are extracting a primary product from a palm, many by-products and salvage products left over from the process are also put to use. This "integrative product development" system, if employed in an agricultural setting, could be effective in creating more environmentally sound extraction processes (Johnson, 1996). Traditional peoples have also found many uses for palms capable of growing in land unsuitable for other plant growth. Moreover, palms are often biologically suited to produce yields with little to no input on marginalized land (Balick, 1985). Growing palms in these spaces could offset pressure on lands needed for other food crops. Ironically, for humans to adapt and survive in a progressive future, they will desperately need to return to ancient, evolutionary palm innovations, and the innovative wisdom of indigenous peoples

Chapter II

Old World and Australasian Palm Medicine: An Update of the Last Two Decades

Background

Since the proposed emergence of the palm tree family's origin in the lower Cretaceous (Dransfield et al., 2008), palms have spread throughout the world and become a dominant element in various ecosystems and in the lives of humans. Palms are distributed mainly in the tropics and the subtropics. The most species-rich areas for palms are tropical rainforests, but they occur commonly in warm seasonal and semi-arid habitats as well (Dransfield et al., 2008). Most palms exhibit a continuous flowering phenology and thus represent year-round sources of nectar, pollen, and fruit for countless invertebrates and vertebrates (Zona and Henderson, 1989). In worldwide economic importance, palms rank third behind grasses and legumes. They rank first, however, in the lives of tropical indigenous and rural communities as food and fuel sources, and as the most important source of construction materials, especially in the lives of forest peoples (Balick, 1984; Boom, 1988; Phillips and Gentry, 1993; Johnson, 1996). In the tropics and subtropics, many palms serve as the sole biological foundation in maintaining subsistence systems with cultures dependent on them (Ellen, 2001).

There are seemingly ceaseless number of uses in almost every use category for palms due to the intimate relationship that has developed between humans and this plant family. Almost every conceivable part and physiological product of palms have been co-opted to meet the needs of people from small bands of shifting agriculturalists to rising empires. Despite this fact, palms as sources for therapeutic compounds have been almost entirely ignored, especially for palms occurring in the Old World and Australasia.

More than a quarter of a century ago, Plotkin and Balick (1984) were the first to note the lack of interest in palms as novel sources of medicine. Monocotyledons have not produced even remotely close to the number of bioactive molecules as have been gleaned from the dicots, which Plotkin and Balick suggested was a possible reason for why palms had been ignored so far in drug screening trials. To ascertain the degree to which palms were used medicinally, they provided a thorough review of all medicinal palm uses up to that time. However, their study included the ethnomedicinal uses known only for Neotropical palms.

A recent paper by Sosnowska and Balslev (2009) extended this review of ethnomedicinal uses of Neotropical palms to include the last twenty-five years. Their synopsis demonstrated that there has been a pronounced increase in the amount of biomedical research focusing on medically relevant palm compounds produced by American palm species. These biomedical studies have analyzed the effectiveness of palm medicines as proposed by ethnomedicinal research. As such, they addressed the significant findings of all relevant biomedical studies for New World species.

Similar reviews have never been carried out for the remainder of the world's palms. There are an estimated 2800 palm species occurring worldwide (Dransfield et al., 2008). Of those, around 2000 grow in the Old World and Australasia and eight hundred in the New World. Matching the immense palm species diversity in these regions is the myriad cultures practicing traditional medicine. Thus, the goal of this review is to provide, from an extensive literature search, an analysis and synthesis of all medicinal uses and results from ethomedicinal and biomedical studies conducted in the last two decades for Old World and Australasian palms. I limit this study to the previous two decades to parallel the work of Sosnowska and Balslev (2009). First, I provide a general overview of uses and the number of reported uses in relation to numbers of taxa per subfamily and general importance of particular species. I then provide a summary of uses (Table 1, 2) of Old World and Australasian species.

Methods

In searching for relevant literature, biological databases and library resources at The University of Texas at Austin were utilized. In addition, Google Scholar was used as a supplementary search engine to provide additional source material. The information found and presented here is organized according to the most recent and accepted palm classification scheme. Species are placed in ascending order, beginning with the most basal genus (Dransfield et al., 2008). All species recorded with uses were checked against the online World Checklist of Selected Plants Families (Palmae). In cases where uses were associated with synonyms, named taxa were transferred over to stabilize nomenclature and to be included with the most recently accepted name for a species. Listed with each species are all the recorded medicinal uses and parts of a palm used. All medicinal uses presented in the literature for symptomatology not recognized in conventional or Western medicine were excluded. Such a preclusion was not intended as a value judgment on the merit of indigenous symptoms without equivalents elsewhere, but only to limit the scope of this paper. Uses were included, however, in instances where a species was described as solely being medicinal. Biomedical reports were only included if the results from the studies were deemed significant.

Results and Discussion

This study found medicinal use accounts for 76 of the close to 2000 species of Old World and Australasian palms (Table 1). If this number is added to the number given by Sosnowska and Balslev (2009), the total number of palm species currently found to be used in a medicinal context worldwide is around 182. Here, it was also discovered that 33 of the 115 Old World and Australasian palm genera contain species of potential medical importance.

Medicinal uses for palms in the Old World and Australasia occur in all five of the palm subfamilies. Generally, as the number of useful species in each subfamily increases, so do the number of uses; the Coryphoideae deviate from this trend (Fig. 1). Four species, two species in *Phoenix* and two in *Borassus* inflate the number of uses in the Coryphoideae. Both *Phoenix dactylifera* and *Phoenix sylvestris*, the Date Palm and the Silver Date Palm respectively, together have a few dozen medicinal uses. Not surprising, since date palms have been linked to human health and religion for close to six thousand years, they provide an almost unrivaled number of uses (Schultes, 1974). Both species of *Borassus* listed, *B. flabellifer* and the recently described *B. akeassii*, which had been previously confused with *B. flabellifer*, together have the second highest number of recorded medicinal uses. Similar to the date palm, *B. flabellifer*, known commonly as the Toddy Palm or palmrya, is among the most highly utilized palms in the world (Bayton, 2006). The elevated number of uses in Arecoideae is mainly due to the remainder of the world's most economically important palms. This subfamily does, however, still have the highest number of representative medicinally useful palm species. The three species with the bulk of medicinal uses are *Cocos nucifera* (coconut palm), the most important palm to humans worldwide; *Elaeis guineensis* (African oil palm), and *Areca catechu* (betel nut).

By plotting the number of medicinal uses across genera in individual subfamilies, and ignoring the most highly useful genera mentioned above, the number of uses clearly increases in parallel with the total number of species present within a genus. Two of the most species rich genera in Palmae are placed within the subfamily Calamoideae. *Calamus* and *Daemonorops* provide a wide range of uses and are the most important sources of rattan in Equatorial Africa and the tropical and subtropical regions of Asia and Australasia. Only a relatively small proportion of species in each genus have medical value, yet the fruits of six species of *Daemonorops* produce resin much revered in traditional medicine and known as

Dragon's blood (Fig. 2). Traditional pharmacopeias prescribe Dragon's blood as a potent antimicrobial, styptic, and antithrombotic (Gupta et al., 2008).

Of all genera in the Coryphoideae, the genus *Phoenix* contains the greatest number of species with biodynamic uses. Three of these species (*P. paludosa*, *P. humilis*, and *P. pusilla*) are especially important to indigenous peoples living on the Indian subcontinent. The two genera with the greatest number of species, *Arenga* and *Livistonia*, have not been recorded as being especially medically important (Fig. 3).

The Arecoideae is the largest and most diverse of all the palm subfamilies. Independent of those species with an extraordinary number of uses (*Cocos nucifera*, *Elaeis guineensis*, *Areca catechu*, and *Borassus spp*.), genera within this subfamily accrue increasing medicinal importance with greater species numbers (Fig. 4). The two genera with the greatest number of medicinal uses are also known to be the two most morphologically and ecological diverse genera in the entire palm family. Species of the incredibly varied *Dypsis* are used as sources for cough suppressants. Many species of this genus are harvested in Madagascar and the Comoros Islands for their heart or tender meristematic region. A few species of *Dypsis* listed in this study have been documented as having poisonous hearts (Byg and Balslev 2001a; Byg and Balslev, 2001b; Dransfield and Beentje, 1995). All species of *Pinanga* listed in this study are employed as betel nut substitutes in Malaysia and India where betel nut use (*Areca catechu*) is highly prevalent. In the same way the betel nut is used, the seeds of *Pinanga* species are masticated in conjunction with a leave of *Piper betle*

(Piperaceae) and a small amount of lime or calcium hydroxide. It has not been reported whether any of the species used as betel nut substitutes contain compounds similar to biodynamic alkaloids found in the betel nut: arecoline, arecain, and guvacine (Witono et al., 2002; Martin et al., 2002).

If medicinal uses are sorted and compared among taxonomic tribes, the same main medically important palms mentioned above break the trend of increased number of species correlated with an increased number of medically relevant use accounts (Fig. 5).

All palm fruits are considered drupes and are highly variable in many morphological characteristics. They are the structure most commonly utilized as a source for therapeutic agents (Fig 6). Some notable genera with medicinally important fruit uses are: *Daemonorops* spp. (Dragon's fruit), *Phoenix* spp. (date palm and relatives), *Hyphaene spp* (doum or gingerbread palms), *Borassus spp*. (toddy or wine palms, palmyra), *Elaeis guineensis* (African oil palm), *Cocos nucifera* (coconut), and *Areca catechu* (betel nut).

Seed numbers vary within palm fruits from one to close to a few dozen. Across Southeast Asia the seed of the betel nut palm is crushed into a powder for oral application to be used as a mild stimulant and as important therapeutic agent in treating blood, genitourinary and gastrointestinal disorders, and infections from many microbes (Gurib-Fakim and Brendler; 2004, Khare, 2004; Ranjan, 1999; Chuakul, 2005). Most other seeds are either used as betel nut substitutes or as a source for topically applied medicinal oils (*Cocos nucifera* and *Elaeis guineensis*). The largest seed in the world is produced by *Lodoicea maldivica* (coco-de-mer or double coconut), which occurs only in Seychelles Islands. In Ayurvedic medicine, many disorders are treated by converting the seed of this species into powder for oral application and directly eating its liquid endosperm (Khare, 2004).

Palm roots exhibit determinate growth at the adult stage of growth and are replaced periodically by lateral adventitious roots extending from each growth internode, usually at the base of the stem. The harvesting of palm roots does not, therefore, endanger the palm and can be done sustainably. Being relatively pliable and succulent, they are most commonly pounded or mashed for creation of an oral decoction. Next to fruits, they are the preferred structure of choice for medicinal purposes. They are used as: antihelmintics, antimicrobials, anti-poisons, antipyretics, analgesics, and for respiratory infections and genitourinary disorders.

All parts of palm leaves have been recorded as being used for medicine. However, the leaflets that are chosen in greater frequency over the rachis and petiole. Leaflets are usually dried or burnt and converted to ash before application and used in poultices and decoctions.

Most of the remaining medicinal uses are derived from palm stems or meristematic regions of the stem. Palm hearts are eaten usually as a foodstuff or by some people very infrequently and only in times of famine. A few studies indicate their use as a medicinal. Mostly, the heart is important medically only as a purported poison (Martin et al., 2002; Barrow, 1998; Panhwar and Abro, 2007; Byg and Balslev, 2001a; Byg and Balslev, 2001b). Non-meristematic stem regions are harvested for pith and fibers, which have a multitude of medicinal qualities, such as: analgesics, antimicrobials, and as agents for respiratory infections and digestive and sexual disorders.

After collecting all accounts of medicinal uses, I partitioned them into use categories adapted from Sosnowska and Balslev (2009) and Lewis and Elvin-Lewis (2003). Old World and Australasian palms are used primarily for digestive tract problems, as opposed to Neotropical palms, which most commonly are used to treat pain (Fig. 7). Digestive disorders, however, do not fall far behind as a use category for Neotropical palms (Sosnowska and Balslev, 2009). Other major significant use categories include: genitourinary, dental hygiene, and antimicrobial. Medicines from palms, therefore, are most commonly employed for menstrual problems, as the main constituents in pastes to prevent tooth decay and bad breath, and as potent therapeutics preventing or mitigating bacterial, viral, fungal, and parasite infections.

The greatest species richness for palms occurs in Asia. Specifically, in the biogeographical region known as Malesia, which includes the Malay Peninsula, Indonesia, Philippines, and New Guinea. This pattern corresponds to the region with the highest number of medicinally important species and the number of uses they provide (Fig. 8). The greatest number of uses has been documented on the Indian subcontinent, due to the majority of studies being conducted there. By contrast, the palm flora of Africa is poor, especially when taking into account the great size of the continent. The inclusion of Madagascar, an island with one of the richest endemic palm floras on the planet, and most highly utilized palms (many of which are most often adopted for use in West Africa) makes the African continent second in overall importance for producing medicinal palm uses (Fig. 10). Outside of Malesia, the Indian Ocean Island and South Pacific regions represent especially species rich areas with high endemism. Many of the species occurring in these regions have been documented as providing a range of economically important products, but their medical uses are depauperate. Recent studies in Fiji and Micronesia have uncovered many medicinal palm uses found in these regions, thus meriting more research focused on the remainder of palm species in these regions (Fig. 11).

In the past few decades, there has been a significant increase in pharmacological and biomedical studies qualifying and quantifying the precise compounds and biological processes acting as therapeutic agents in Neotropical palms. My study has found a similar trend for palms distributed throughout the remainder of the world. Since 1990, biomedical research on Old World and Australasian palms has grown almost in parallel, yet in lower numbers, with regional ethnobotanical studies (Fig. 12). The biggest share of these studies has focused entirely on the most economically important palms with cosmopolitan use (Fig. 13).

The largest number of studies has been focused on substantiating many of the purported medicinal uses of *Cocos nucifera.* Results indicate many parts of the Coconut are significantly effective in combating microbial infections, gastrointestinal and cardiovascular disorders, and as therapeutic alternatives for pain and inflammation (Costa et al., 2010; Intaphuak et al., 2010; Esquenazi et al., 2002; Nneli and Woyike, 2008; Mendonca-Filho et al., 2004; Chakaborty and Mitra, 2008; Alleyne et al., 2005; Adams and Bratt, 1992).

Similarly, a significant proportion of biomedical research has sought to confirm the proposed therapeutic effectiveness of *Areca catechu* uses*.* The findings suggest betel nut is useful as a general antimicrobial, but is especially effective in treating broad fish tapeworm (*Diphyllobothrium latum*) and tuberculosis (*Mycobacterium tuberculosis*)(Khan and Balick, 2001; Guatam et al., 2007). Other studies also confirm betel nut as a functional treatment for inflammation and as an antidiabetic (Lee and Choi, 1998; Chempakam, 1993).

The remainder of biomedical studies supports the proposed range of uses for several species as having significant therapeutic activity against various diseases or disorders (Table 2). A few studies documented and confirmed palm pollen and betel nut as allergen sources (Singh and Kumar, 2003; Taylor et al. 1992). There have also been a few reported and confirmed cases of anaphylaxis induced from the consumption of palm heart and coconut endosperm (Singh and Kumar, 2003; Blanco et al., 2007; Mayoral et al., 2006; Teuber and Peterson, 1999).

Conclusions

For millennia, humans have depended on a keen awareness of their environment and relied on exhaustive trial and error for the compilation of a rich assemblage of medicinally important plants. For the past century, this traditional medicinal knowledge had been supplanted by a conventional medical system, which, despite relying on many of the therapeutic compounds derived from traditional or alternative medical paradigms, is narrowly focused on the specific processes and organisms involved in disease and disorder states. Lewis and Elvin-Lewis (2003) report that seventy to ninety percent of the world's population still receives health care primarily by alternative or traditional means. They also list the factors responsible for many Western-living people beginning to choose complementary and alternative medicine or CAM over a conventional approach; two of the biggest factors are an exponential increase in health care costs and the avoidance of holism in conventional patient care.

As interest has grown in CAM, so too has ethnobiological and ethnomedicinal research (Pieroni et al., 2005). Knowledge of the medicinal uses of palms has benefitted from this resurgence; ethnobotanical studies of palms have grown continuously over the last two decades, as has been indicated here and in Sosnowska and Balslev (2009). Biomedical and pharmacological studies of palms still lag behind ethnobotanical studies but have increased in parallel with them. This trend suggests that a continued focused effort on ethnobotanical studies in palms would be a prerequisite for future advances in drug production from palms. More ethnomedicinal palm research would also act to reinvigorate an interest in palm medicines being used in a traditional manner and would encourage species conservation and the conservation of important cultural practices to which they serve as a foundation.

Appendix

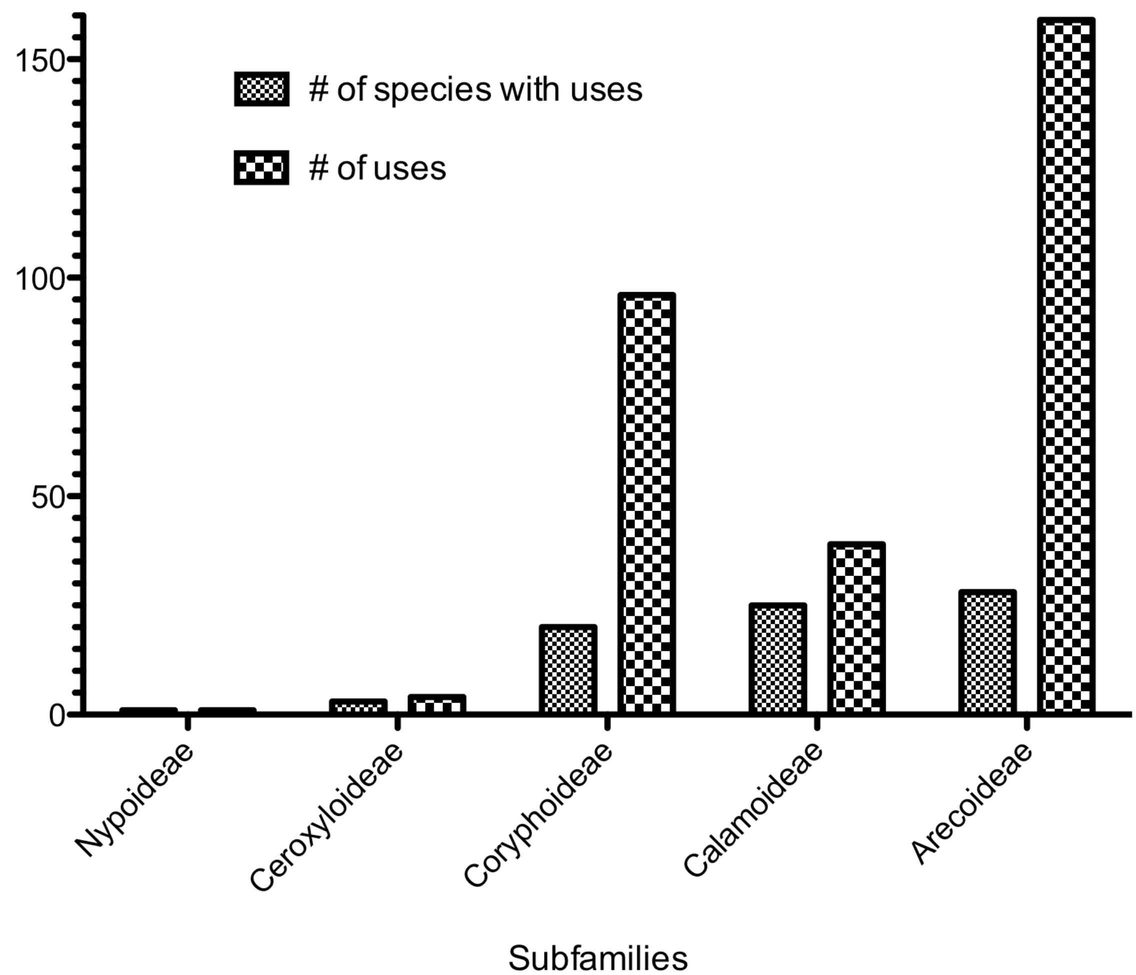

Fig. 1. Medicinal use relationships among palm subfamilies.

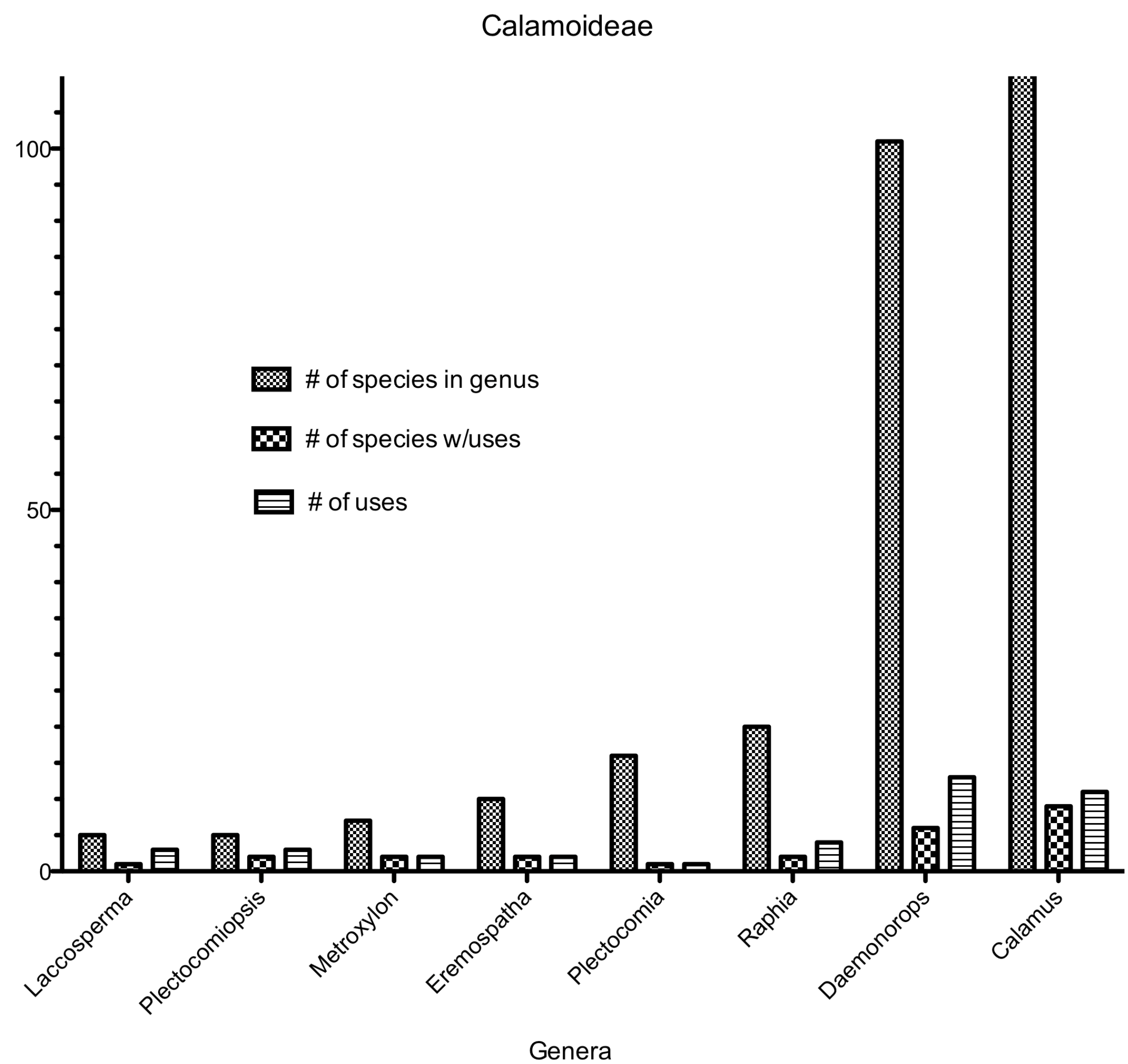

Fig. 2. Medicinal use relationships among genera of Calamoideae.

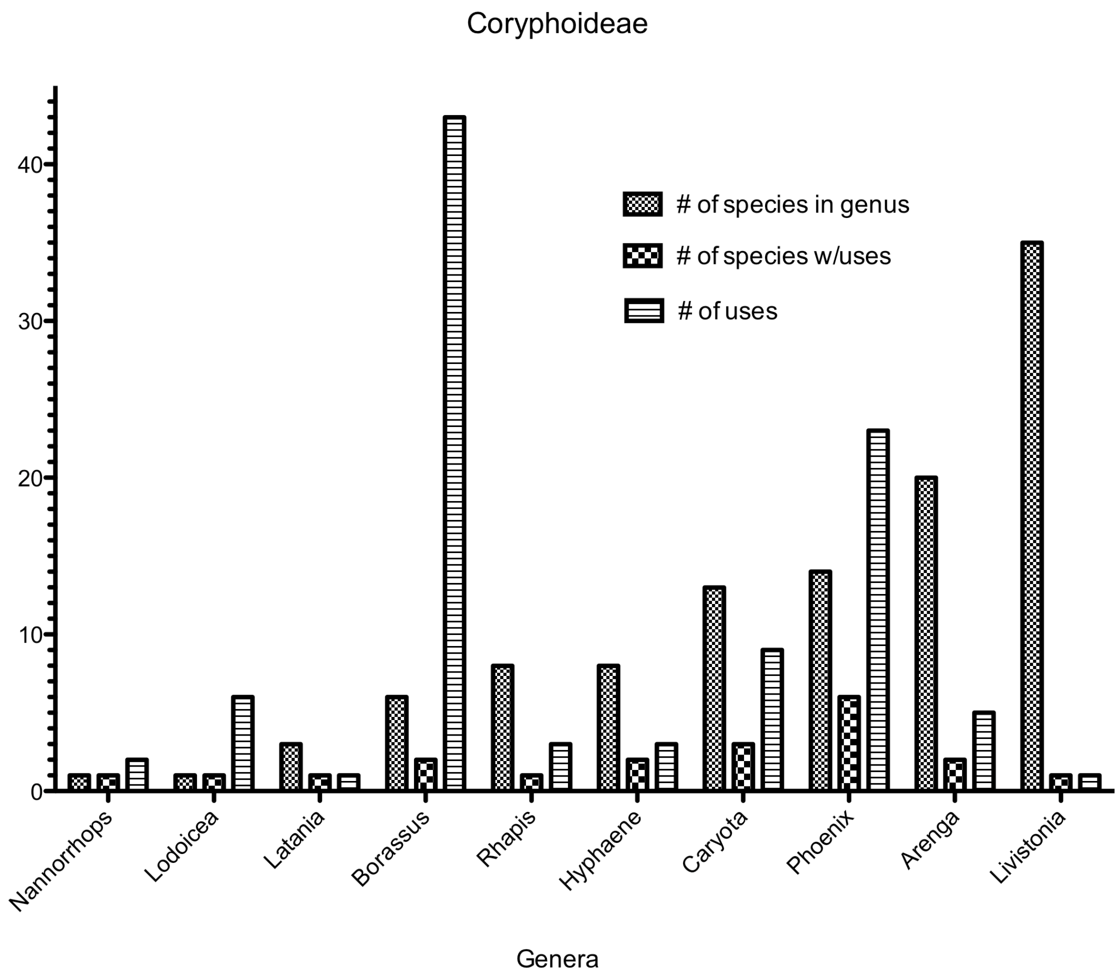

Fig. 3. Medicinal use relationships among genera of Coryphoideae.

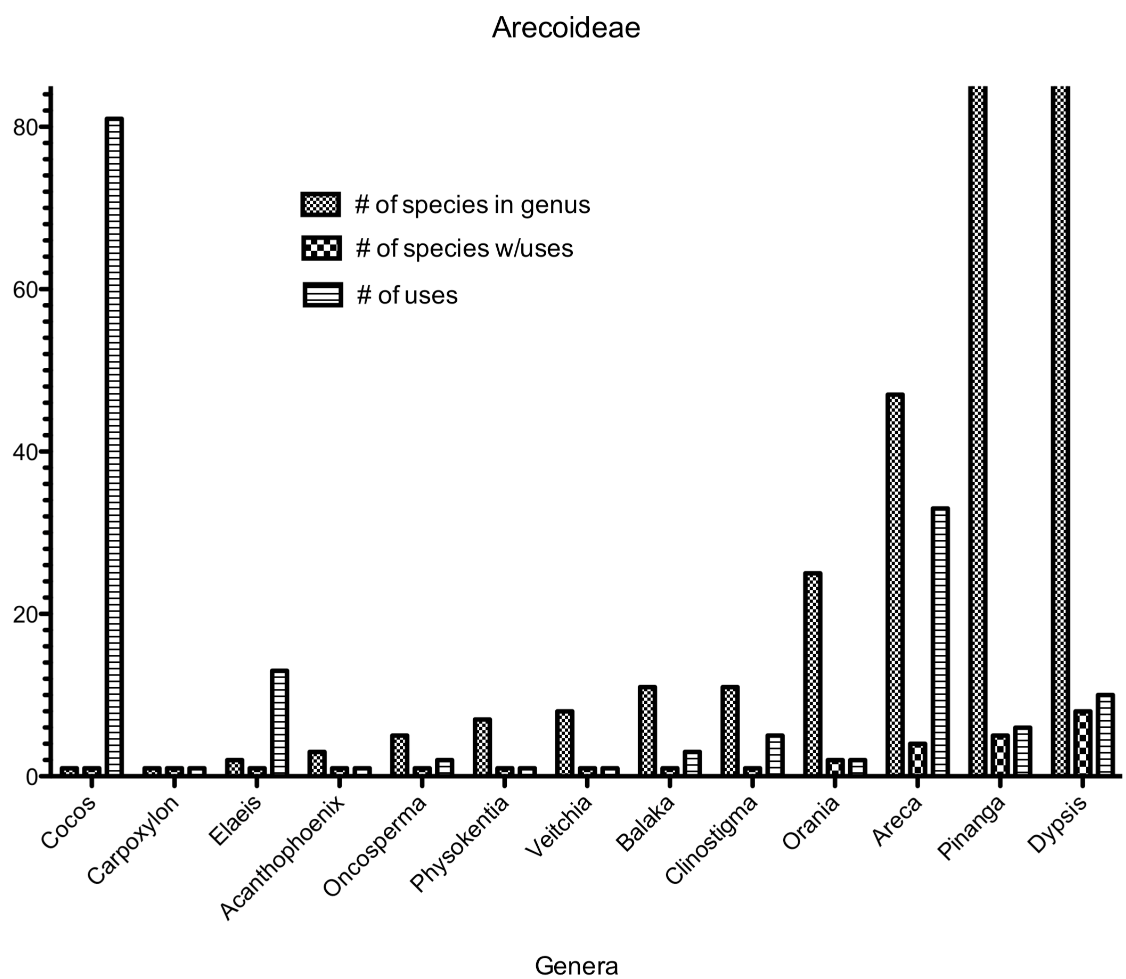

Fig. 4. Medicinal use relationships among genera of Arecoideae.

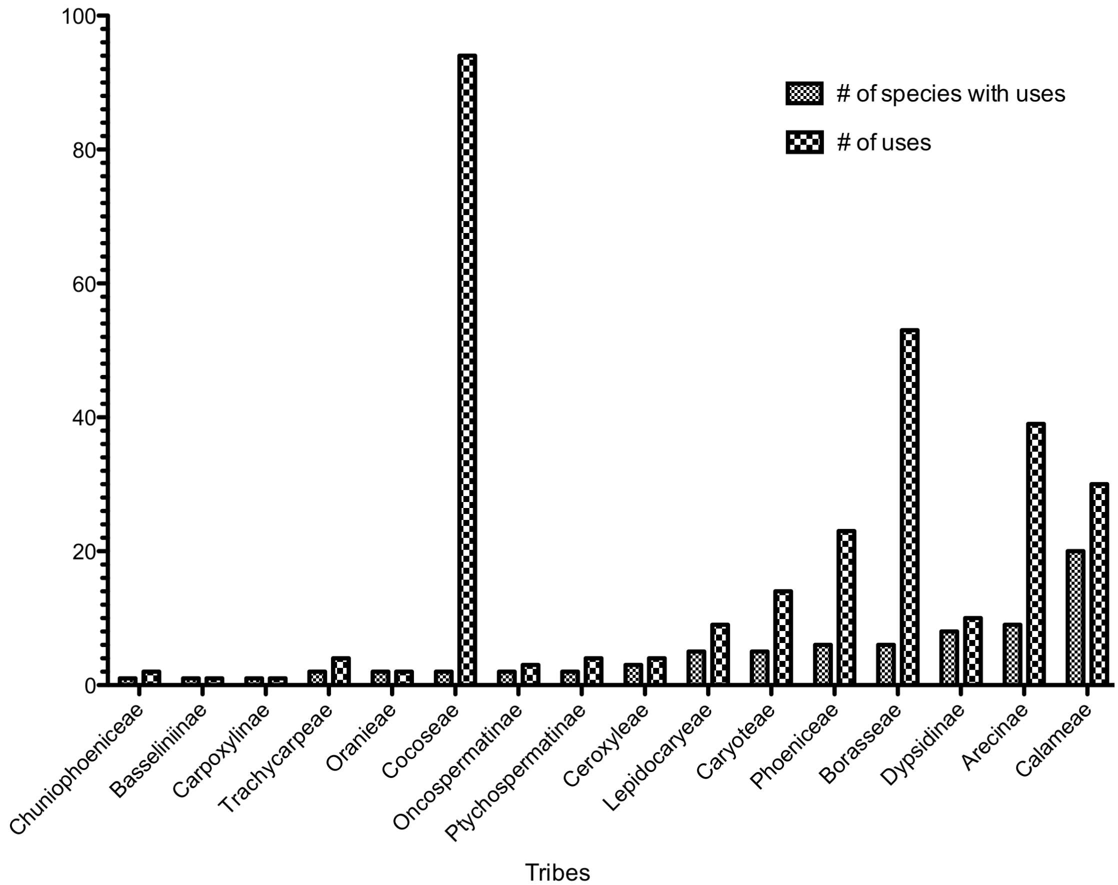

Fig. 5. Medicinal use relationships among palm tribes.

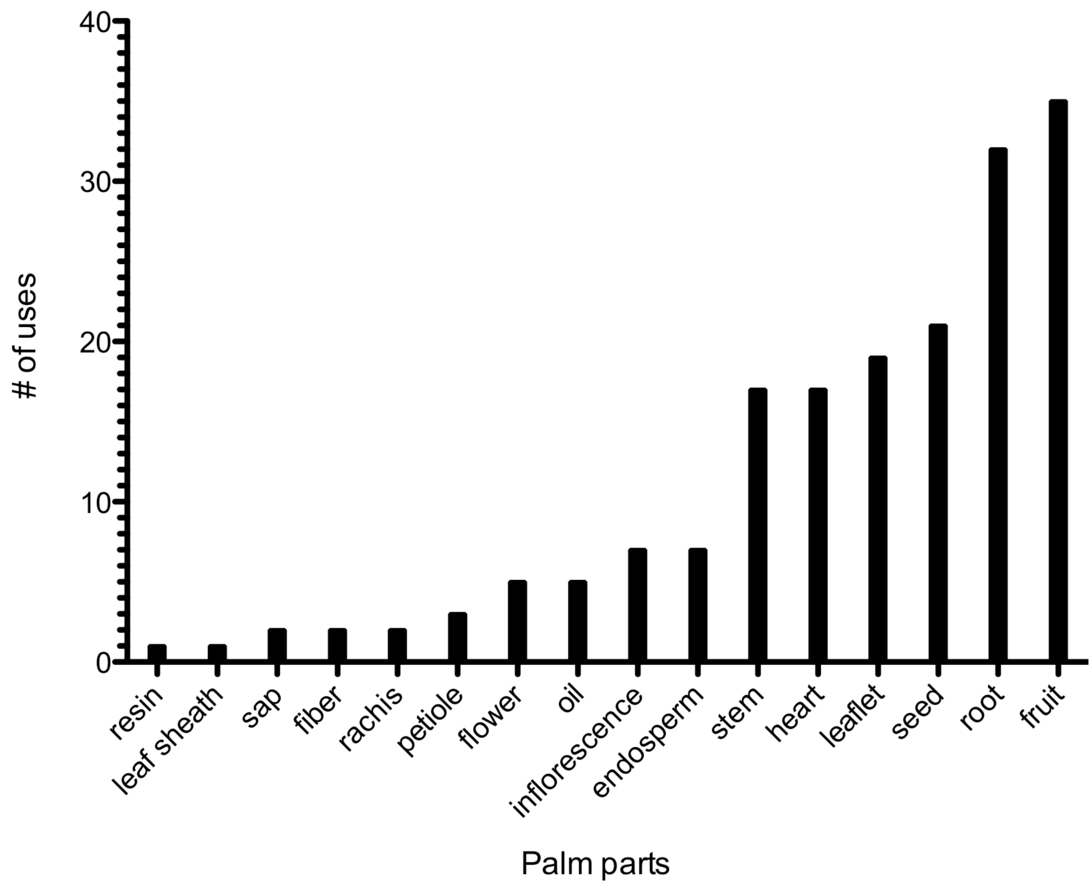

Fig. 6. Medicinal use relationships among palm parts.

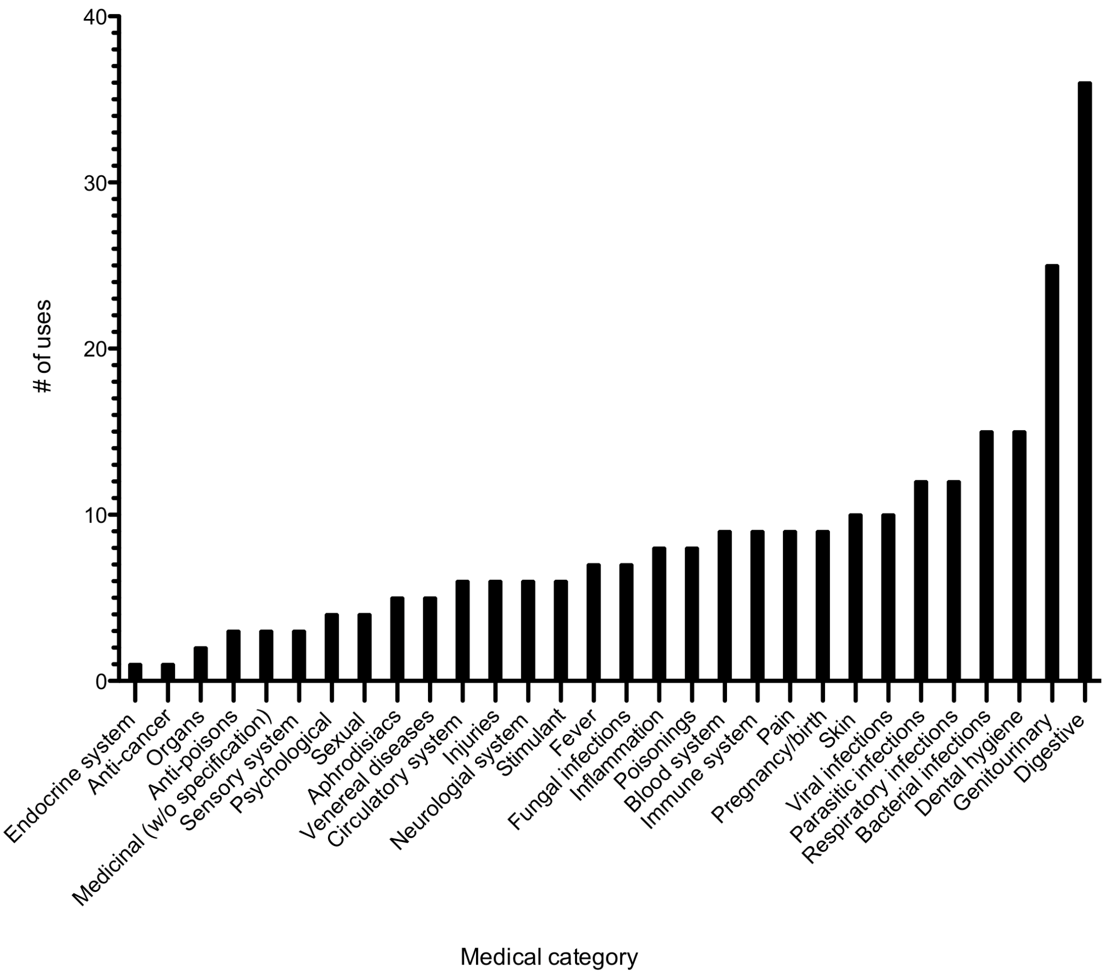

Fig. 7. Medicinal use relationships among medical categories.

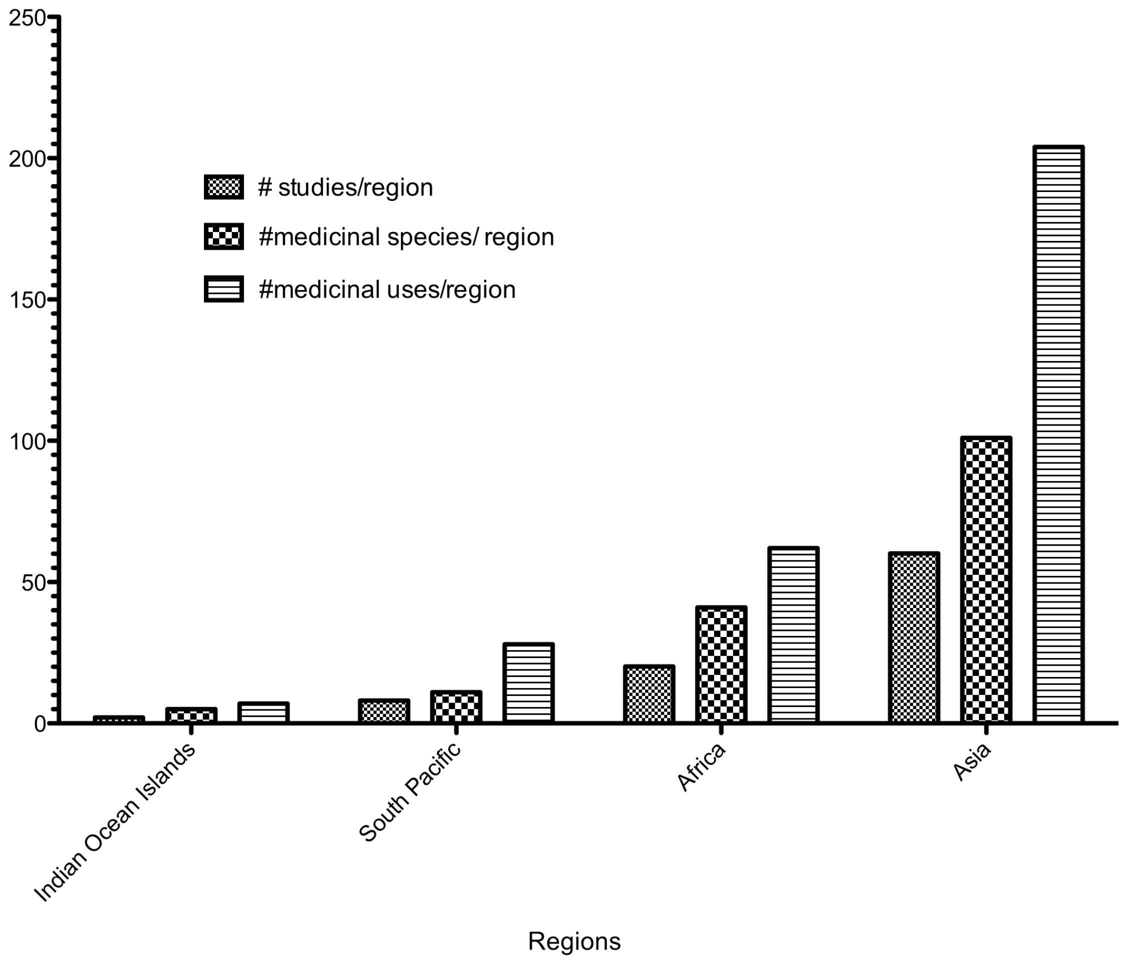

Fig. 8. Medicinal use relationships among Old World and Australasian regions. Note: Africa's apparent high use of palms for medicinal uses is due to the inclusion of Madagascar

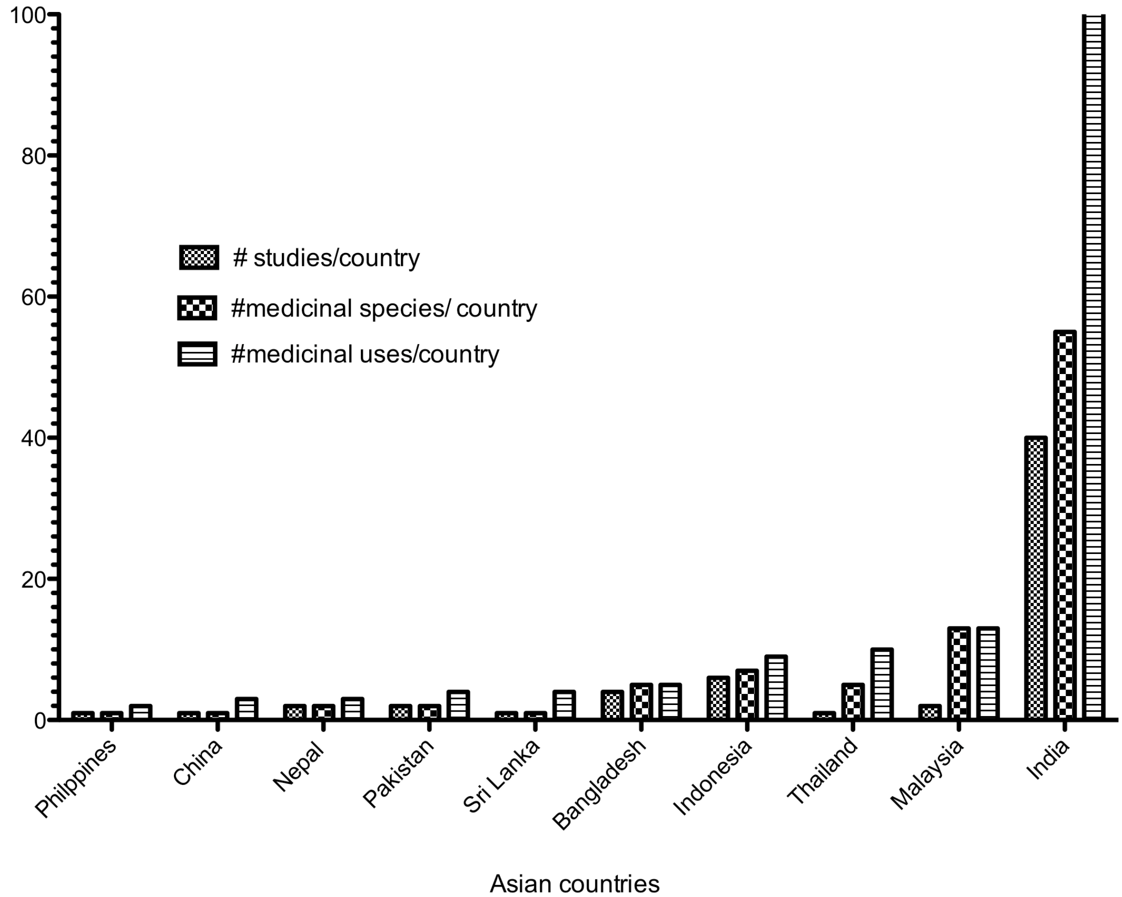

Fig. 9. Medicinal use relationships among Asian countries.

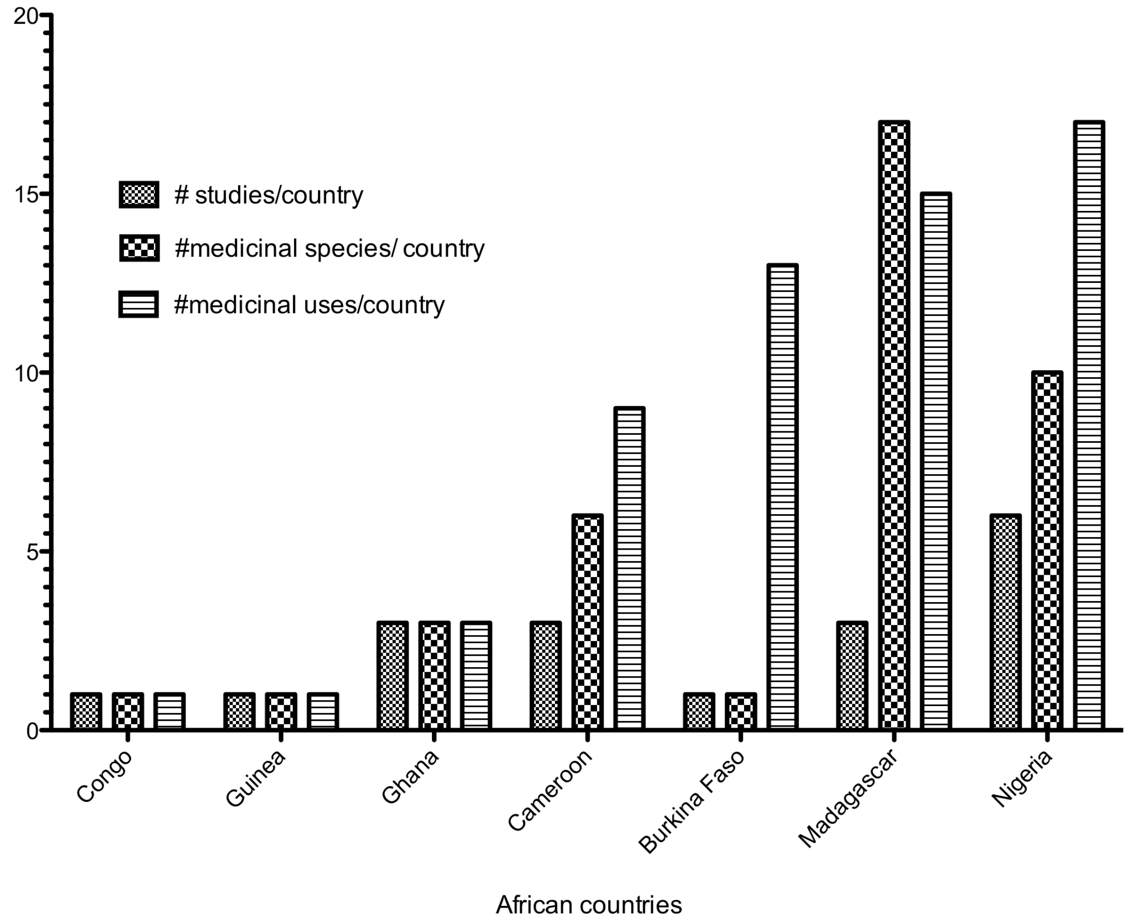

Fig. 10. Medicinal use relationships among African countries.

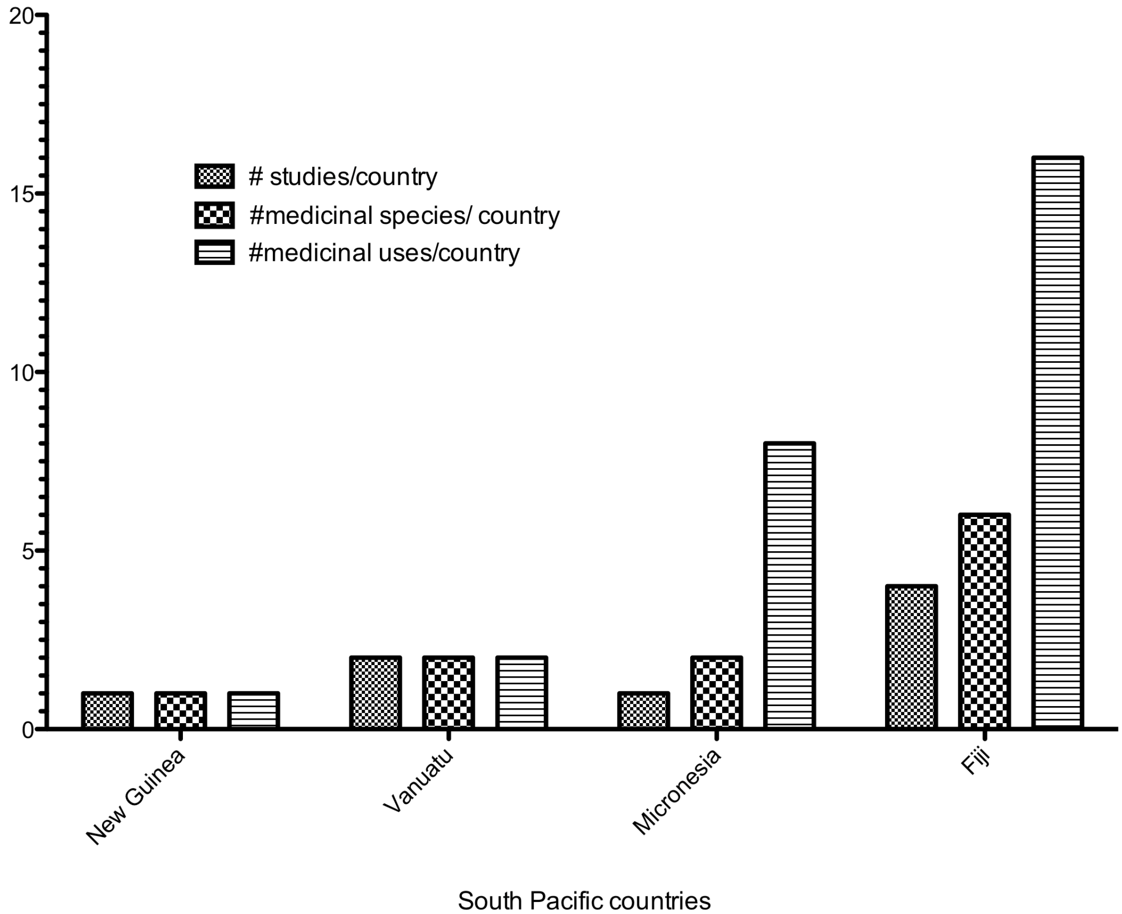

Fig. 11. Medicinal use relationships among South Pacific countries.

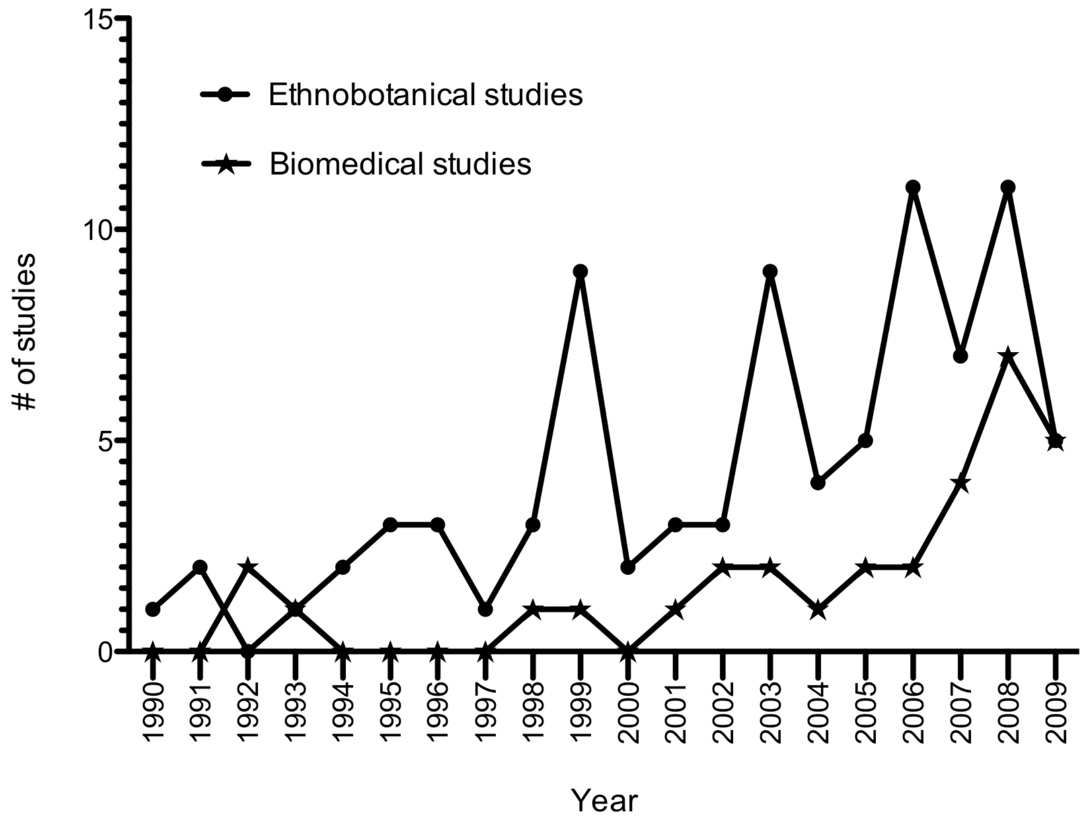

Fig. 12. Number of ethnobotanical and biomedical studies in Old World and Australasian palms annually for the last twenty years.

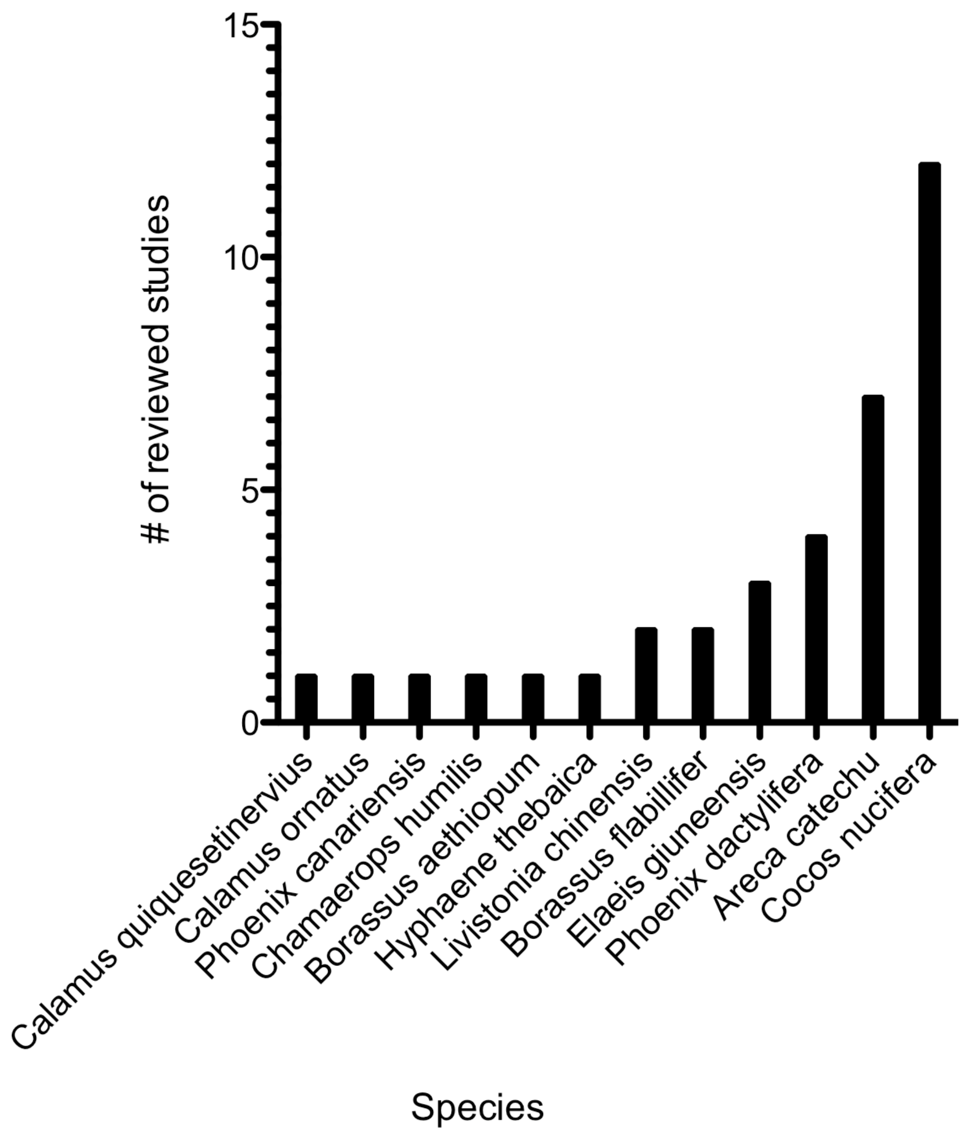

Fig. 13. Old World and Australasian palm species represented in biomedical studies.

Table1. Ethnomedicinal studies of Old World and Australasian palms. The arrangement of palm genera follows Dransfield et al. (2008). Superscripts link recorded uses and the source of the report. Palm parts used are indicated as follows: end= endosperm; fb= fiber; fl= flower; frt= fruit; hrt= heart; inf= inflorescence; lfl= leaflet; ls= leaf sheath; o=oil; pt= petiole; rch= rachis; rs= resin; rt= root; sp=sap; sd= seed; st= stem.

Taxon	Medicinal use	Parts used	Reference
Calamoideae:Lepidocaryeae			
Eremospatha			
Eremospatha haullevilleana	abortifacient	sp	Sunderland, 2004
Eremospatha macrocarpa	syphillis	rt	Sunderland, 2004
Laccosperma			
Laccosperma opacum	rheumatism, cough, fracture	st	Jiofack et al., 2009
Raphia			
Raphia farinfera	digestive disorders[1], haemorrhagia, laxative[2]	fb, frt, inf	Byg and Balslev, 2001[1], Gurib-Fakim and Brendler, 2004[2]
Rhapia mombuttorum	medicine		Betti, 2004
Raphia vinifera	measles	sp	Nwosu, 1998
Calamoideae:Calameae			
Metroxylon			
Metroxylon amicarum	diarrhea, fever, seizure	st, rt	Balick, 2009

Metroxylon sagu	stomachache[1], cough[2]	lfl, rt	Roosita et al., 2008[1], Martin et al., 2002[2]
Plectocomia			
Plectocomia mulleri	contraceptive: men and woman	st	Martin et al., 2002
Plectocomiopsis			
Plectocomiopsis geminiflora	nausea, hypertension	hrt	Martin et al., 2002
Plectocomiopsis mira	poisonous	hrt	Martin et al., 2002
Calamus			
Calamus acuminatus	boils	hrt	Martin et al., 2002
Calamus erectus	gastrointestinal	sd	Rethy et al., 2010
Calamus deerrratus	edema	lfl	Sunderland, 2004
Calamus latifolius	fracture	st	Roy et al., 2008
Calamus merrillii	Menstruation, hemorrhage	rt	Langenberger et al, 2009
Calamus ornatus	stomachache, hypertension	hrt	Martin et al., 2002
Calamus rotang	febrifuge[1], antidiabetic[2]	st, frt	Rethy et al., 2010[1], Chhetri et al., 2005[2]
Calamus thwaitesii	contraceptive	st	Bhandary et al., 1995
Calamus viminalis	urogenital and gynaecological	lfl	Dagar and Dagar, 1999
Daemonorops			
Daemonorops didymophylla	antibacterial, antibacterial, anitfungal, antiviral, antitumor, hemostatic, antithrombitic	rs	Gupta et al., 2008

Daemonorops draco	antibacterial, anitfungal, antiviral, antitumor, hemostatic, antithrombitic[1], stypic, astringent, antispetic, menorrhagia, diarrhea, dysentery, dentrifices[2]	rs, frt	Gupta et al., 2008[1], Khare, 2004[2]
Daemonorops micracantha	antibacterial, anitfungal, antiviral, antitumor, hemostatic, antithrombitic	rs	Gupta et al., 2008
Daemonorops monticola	antibacterial, anitfungal, antiviral, antitumor, hemostatic, antithrombitic	rs	Gupta et al., 2008
Daemonorops polita	antibacterial, anitfungal, antiviral, antitumor, hemostatic, antithrombitic	rs	Gupta et al., 2008
Daemonorops rubra	antibacterial, anitfungal, antiviral, antitumor, hemostatic, antithrombitic	rs	Gupta et al., 2008
Nypoideae			

Nypa			
Nypa fruticans	toothache	rt, lfl	Ganesan, 2008
Coryphoideae:Phoeniceae			
Phoenix			
Phoenix dactlifera	toothache, pain and inflammation, rheumatiod arthritis, anaemia, tuberculosis, piles, hepatitis, diabetes	rt, frt	Kumar et al., 2006
Phoenix humilis	laxative	frt	Kumar et al., 1999
Phoenix paludosa	fever and inflammation	frt	Nayak et al., 2003
Phoenix pusilla	bad breath	frt	Ganesan, 2008
Phoenix reclinata	urinary infections	hrt	Barrow, 1998
Phoenix sylvestris	asthma, fever, diarrhea, hemorrhage, aphrodisiac, spermatogenic, bronchitis[1], diuretic[2], antidiabetic[3], laxative, cough[4], toothache[5], diarrhea[6], stomachache[7], toothache[8], cough, asthma, fever, diarrhea, hemorrhage, aphrodisiac bronchitis[9]	frt, lfl, sp, rt, rch	Khare, 2004[1], Deokule, 2006[2], Bhatt et al., 2003[3], Kapur, 1990[4], Ahmad and Muhammad, 2008[5], Behera et al., 2006[6], Acharya and Pokhrel, 2006[7], Ganesan, 2008[8], Khare, 2004[9]
	asthma, fever, diarrhea, hemorrhage, aphrodisiac, spermatogenic, bronchitis[1],		Khare, 2004[1], Deokule, 2006[2], Bhatt

Coryphoideae:Trachycarpeae			
Rhapis			
Rhapis laosensis	stypic, rheumatism, blood circulation	pt, lfl, ls, rt, frt	Hastings, 2003
Livistonia			
Livistonia jenkinsiana	substitute for betel nut	sd	Bhuyan, 2003
Coryphoideae:Chuniophoeniceae			
Nannorrhops			
Nannorrhops ritchieana	diarrhea, dysentery	lfl, hrt	Panhwar and Abro, 2007
Coryphoideae:Caryoteae			
Caryota			
Caryota mitis	abnormal menstruation	rt	Chuakul, 2005
Caryota ophiopellis	medicine	rt, st	Dupuyoo, 2005
Caryota urens	gastric ulcers, boils, tooth ailments[1], laxative, headache[2], betel nut substitute[3], tooth decay[4]	hrt, st, sd, frt, rt	Everett, 1995[1], Kothari and Rao, 1999[2], Partha and Hossain, 2007[3], Bhandary et al., 1995[4]
Arenga			
Arenga pinnata	bladder stones, wine[1], sore eyes[2]	rt, inf, lfl	Mogea et al, 1991[1], Harada et al., 2005[2]

Arenga wightii	jaundice[1], birth defects[2]	st, lfl, inf	Sasidharan and Augustine, 2006[1], Augustine et a., 2010[2]
Coryphoideae:Borasseae			
Hyphaene			
Hyphaene guineensis	colic, diarrhea	frt	Mitaliya and Bhatt, 2003
Hyphaene thebaica	hypertension	frt	Jiofack et al., 2009
Latania			
Latania vershaffeltii	venereal disease	rt	Gurib-Fakim and Brendler, 2004
Lodoicea			
Lodoicea maldivica	pediatric disorders, skin disorders, anthelmintic, antidiabetic, antibilious, antacid	sd, end	Khare, 2004
Borassus			
Borassus akeassii	sexual impotence, stomach aches, sore throats, constipation, bronchitis, intestinal parasites, earaches, beginning of deafness, cold, dermatosis, delay of dental thrust, sexual impotence, intestinal	rs, lfl, inf, rs, sp,rt	Yameogo et al., 2008
	sexual impotence, stomach aches, sore throats, constipation, bronchitis, intestinal parasites,		

Borassus flabellifer	rheumatic pain[1], epilepsy[2], antidiabetic[3], jaundice[4], inflammation of breast[5], inflammation of breast[6], diuretic, anthelmintic, dyspepsia, flatulence, skin diseases[7], sterility/contraceptive[8],toothache[9], insomnia, depression, anorexia, retention of urine, dysuria; splenomegaly, skin diseases and wounds[10]	inf, pt, frt, lfl, fl, rt, rch, sp	Sinha et al., 2006[1], Saren et al., 1999[2], Ghosh and Das, 1999[3], Karuthapandi and De Britto, 1993[4], Partha and Hossain, 2007[5], Anisuzzaman et al., 2007[6], Pattanaik et al., 2008[7], Jain, 2004[8], Ganesan, 2008[9], Khare, 2004[10]
Ceroxyloideae:Ceroxyleae			
Ravenea			
Ravenea dransfieldii	poison	hrt	Dransfield and Beentje, 1995
Ravenea glauca	poison	hrt	Dransfield and Beentje, 1995
Ravenea sambiranensis	cough medicine, digestive disorders	hrt	Byg and Balslev, 2001b
Arecoideae:Oranieae			
Orania			
Orania longissquama	poison	hrt	Dransfield and Beentje, 1995
Orania longissquama	poison	hrt	Dransfield and Beentje, 1995

Orania trispatha	poison	hrt	Dransfield and Beentje, 1995
Arecoideae:Cocoseae			
Elaeis			
Elaeis guineensis	stomach disorder, convulsion[1], anticonvulsant[2], syphilis, gonorrhea[3], infectious disease: STD's[4], chronic wounds[5], easy flow menses[6], malaria[7], boils[8], enteritis and constipation[9], medicine[10], stomach disorder, convulsion[11]	o, sd, lfl, st, rt, frt	Nwosu, 1998[1], Okali et al., 2007[2], Jiofack et al., 2009[3], Magassouba et al., 2007[4], Agyare et al., 2009[5], Aiyeloja and Bello, 2006[6], Kayode, 2006[7], Addo-Fordjour et al., 2008[8], Noumi and Yomi, 2001[9], Betti, 2004[10], Nwosu, 1998[11]
Cocos			
	injury[1], scabies[2], inflammation, depression, constipation, fungal, bacterial infection[3], poisoning, gastrointestinal[4], cholera, diarrhea, dysentery, diuretic, menstrual disease [5], ringworm, tinea versicolor, antipyretic[6],		Collins et al., 2007[1], Saikia et al., 2006[2]

injury[1], scabies[2],
inflammation,
depression,
constipation,

Arecoideae:Arecinae			
Arecoideae:Areceae ***Areca***			
Areca catechu	scorpion bite[1], leucoderma patches[2], buccal astringent, anthelmintic[3], incontinence, fever[4], dentrifice[5], astringent, disinfectant, leucorrhoea, menorrhagia, uterine tonic after delivery, sterility, premature ejaculation, dentrifice, diarrhea, flatulence/choleric action[6], aphrodisiac, urinary disorders, astringent, anthelmintic[7], urination problems[8], antiinflammatory, herpes zoster[9], hemorrhage, nerve diseases, worm infection, dental diseases and constipation[10], constipation[11]	rt, sd, st, frt	Harsha et al., 2002[1], Deb et al., 2009[2], Gurib-Fakim and Brendler, 2004[3], Ong and Norzalina, 1999[4], Ganesan, 2008[5], Khare, 2004[6], Ranjan, 1999[7], Roy et al., 2008[8], Chuakul, 2005[9], Shiddamallayya et al, 2010[10], Awasthi, 1991[11]
Areca kinabaluensis	betel nut substitute	sd	Martin et al., 2002
Areca mandacanii	betel nut substitute	sd	Heatubun, 2008
Areca rheophytica	betel nut substitute	sd	Martin et al., 2002

Pinanga			
Pinanga arinasae	betel nut substitute	sd	Witono et al., 2002
Pinanga keahii	betel nut substitute	sd	Martin et al., 2002
Pinanga lepidota	betel nut substitute	sd	Martin et al., 2002
Pinanga manii	pain, ringworm	pt	Subramaniam et al., 1998
Pinanga pilosa	betel nut substitute	sd	Martin et al., 2002
Arecoideae:Basseliniinae			
Physokentia			
Physokentia thurstonii	heart[1], heart[2]	lf, sd	Cambie and Ash, 1994[1], Watling, 2005[2]
Arecoideae:Carpoxylinae			
Carpoxylon			
Carpoxylon macrospermum	contraception	st	Dowe, 1996
Arecoideae:Dypsidinae			
Dypsis			
Dypsis andrianatonga	convalescence	lf	Dransfield and Beentje, 1995
Dypsis crinita	cough	st	Dransfield and Beentje, 1995
Dypsis fibrosa	chronic cough[1], chronic cough[1], cough medicine, pancreatic disease, intestinal worm[2]	st, hrt	Byg and Balslev, 2001b[1], Byg and Balslev, 2001a [2]

Dypsis lastelliana	poison[1], cough medicine[2]	hrt	Dransfield and Beentje, 1995[1], Byg and Balslev, 2001b[2]
Dypsis madagascarensis	aphrodisiac	st	Dransfield and Beentje, 1995
Dypsis nauseosa	poison	hrt	Dransfield and Beentje, 1995
Dypsis pinnatifrons	cough medicine	hrt	Byg and Balslev, 2001b
Dypsis tsaravoasira	pregnancy	hrt	Byg and Balslev, 2001b
Arecoideae:Oncospermatinae			
Oncosperma			
Oncosperma tigillarium	diuretic, antipyretic	rt	Chuakul, 2005
Acanthophoenix			
Acanthophoenix rubra	diuretic	rt	Gurib-Fakim and Brendler, 2004
Arecoideae:Ptychospermatinae			
Balaka			
Balaka seemannii	headache, venereal disease, antimicrobial	st, frt, lfl, rt	Watling, 2005
Veitchia			
Veitchia filifera	abdominal pains	rt	Cambie and Ash, 1994
Arecoideae:Unplaced			

Arecoideae:Unplaced			
Clinostigma			
Clinostigma ponapense	analgesic, dysentery, uterine cancer, eyewash, seizures	rt, fl, frt, st, sd	Balick, 2009
Hydriastele			

Table 2. Biomedical studies of Old World and Australasian palms. The arrangement of palm genera follows Dransfield et al. (2008). Matching numbers indicates multiple publications for one species and associated medicinal uses recorded.

Taxon	Significant findings	Reference
Calamoideae:Calaminae		
Calamus		
Calamus ornatus	antinflammatory, anticancer	Yu et al. , 2008
Calamus quiquesetinervius	cardiovascular protection: vasodilation and platelet aggregation inhibition	Chang et al., 2010
Coryphoideae:Phoenicea e		
Phoenix		
Phoenix canariensis	allergen: asthma	Blanco et al., 2007
Phoenix dactylifera	antimutagenic[1], nephroprotective[2], antiviral: *Pseudomonal*[3], *neuroprotective*[4]	Praveen, 2002[1], Al-Qarawi et al., 2008[2], Sabah and Naji, 2007[3], Majid et al., 2008[4]
Coryphoideae:Trachycar peae		
Chamaerops		
Chamaerops humilis	allergen: analphalaxis	Mayoral et al., 2006
Livistonia		
Livistonia chinensis	antitumor[1], antibacterial[2]	Wang et al., 2008[1], Kaur and Singh, 2008[2]
Coryphoideae:Borasseae		
Borassus		
Borassus aethiopum	poisonous	Waziri et al. ,2010
Borassus flabillifer	inflammation[1], analgesic, antipyretic[2]	Paschapur et al., 2009[1], Paschapur et al., 2009[2]
Hyphaene		
Hyphaene thebaica	anticancer	Abou-Elalla, 2006
Arecoideae:Cocoseae		
Cocos		

Cocos nucifera	anthelmintic[1], anti-inflammatory, analgesic, and antipyretic[2], antibacterial and antiviral[3], antiulcerogenic[4], anaphylaxis[5], leishmanicidal[6], anti-staphylococcal activity[7], antihypertensive[8], burn wound healing[9], gastroenteritis[10], antitumor[11], coronary heart disease, oral rehydration therapy [12]	Costa et al., 2010[1], Intahphuak et al., 2010[2], Esquenazi et al., 2002[3], Nneli and Woyike, 2008[4], Teuber and Peterson, 1999[5], Mendonca-Filho et al., 2004[6], Chakraborty and Mitra, 2008[7], Alleyne et al., 2005[8], Srivastava and Durgaprasad, 2008[9], Adams and Bratt, 1992[10], Kirszberg et al., 2003[11], Khan and Balick, 2001[12]
Elaeis		
Elaeis giuneensis	hepatoprotective[1], antihypertensive activity[2], induces pronounced endothelium-dependent relaxations of the porcine coronary artery[3]	Adeneye and Benebo, 2007[1] Bayorth et al., 2005[2], Ndiaye et al., 2010[3]
Arecoideae:Areceae ***Areca***		
Areca catechu	antimicrobial[1],hypoglycemic activity[2], *Diphyllobothrium latum* infection, inflammatory boweldisease[3],antituberculosis[4],antiinflammatory[5],allergen[6]	Reena and Michael, 2009[1], Chempakam, 1993[2], Khan and Balick, 2001[3], Guatam et al., 2006[4], Lee and Choi, 1998[5], Taylor et al., 1992[6], Singh and Kumar, 2003[7]

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